PILOT-SCALE TREATABILITY STUDY WORK PLAN STEAM ENHANCED EXTRACTION SITE 13 NAVAL AIR STATION ALAMEDA ALAMEDA, CALIFORNIA

Contract Number: N62474-94-D-7430 Delivery Order No. 003

Submitted to:

EFA WEST (Code 0222) Naval Facilities Engineering Command 900 Commodore Drive San Bruno, CA 94066-5006

Submitted by:

Berkeley Environmental Restoration Center University of California at Berkeley 3114 Etcheverry Hall #1750 Berkeley, CA 94720-1750

Revision 1

UNCLASSIFIED March 20, 1996

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Approved by: Kent S. Udell, BERC Principal Inves	Date: 3/20/96
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PILOT-SCALE TREATABILITY WORK PLAN DATED 30 JUNE 1995

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1. INTRODUCTION

This Work Plan is written to specify the design, implementation, and operation of a pilot-scale treatability study of Steam Enhanced Extraction (SEE) at Site 13, Abandoned Oil Refinery, at NAS Alameda. A draft work plan for the treatability study was prepared and submitted to the Navy for review on June 30, 1995. The draft work plan was reviewed by the Navy, CLEAN and Remedial Action Contractors (RAC) (PRC Environmental Management, Inc. and IT Corporation), Department of Toxic Substances Control (DTSC), and the Remedial Advisory Board (RAB). The responses to comments received on the draft work plan from those groups are included in Appendix A. This final Work Plan includes changes that address the comments received, and provides more detailed site and process descriptions.

Based on previous investigations at Site 13, oily material is found in high concentrations below the four-to seven-foot-deep water table. The assessment of feasible in situ technologies to remediate soil and groundwater is recommended prior to a regulatory Record of Decision. In situ restoration options for remediation include biosparging, where air would be injected into the oil bearing zones to stimulate biodegradation, and both bioventing and soil-vapor extraction during dewatering. However, these technologies conducted at ambient temperatures cannot be expected to recover the viscous hydrocarbon phase to a significant extent, and would be inherently slow due to low volatilities, aqueous-phase diffusivities, solubilities, and vapor pressures of the contaminants.

Because the oily material may become more volatile, less dense, and flow more readily when heated, applicable temperature-enhanced in situ technologies are of interest to accelerate the remedial processes. The mechanisms exploited by thermal processes are the reduction of the oil viscosity and oil-water interfacial tension to increase the mobility of the oil, an increase in the difference between the water and oil densities which will enhance upward mobilization of the heated hydrocarbons to the top of the water table, and an increase in the hydrocarbon mixture vapor pressure to enhance distillation of the hydrocarbons from the solid phase to the vapor phase which can be removed through vapor extraction. Thus, thermal processes are expected to be the more rapid of the viable in situ options. An effective process would include significant removal of free phase hydrocarbons produced by the application of steam and removal of the more volatile components of the immobile hydrocarbon mixture through steam distillation. Removal of these components would minimize the potential risks associated with exposure to the residual oily materials.

Applicable thermal heating processes include steam injection, radio-frequency heating, and electrical heating. Steam injection is the least expensive thermal process in terms of energy costs and has the potential advantage of effective displacement of mobile liquid phases. Given the readily available clean steam source from facility steam plants, SEE appears to be particularly attractive for pilot-scale testing at Site 13. There are no structures on the site that would interfere with application of SEE, and there are no immediate planned uses of Site 13. The energy cost for implementation of SEE at Site 13 are expected to be in the range of \$20/yd³ to \$100/yd³ of soil.

The SEE treatability study described in this Work Plan consists of laboratory and field tests. Two laboratory treatability tests for the removal of hydrocarbons have been completed and results are included in Appendices B and C. The results of the tests indicate that SEE is capable of removing some of the more mobile hydrocarbons at Site 13 through steam distillation. Based on the results of these tests, however, SEE appears unlikely to remove an appreciable mass of the total hydrocarbons that are of the high molecular weight fraction. This is consistent with experience at other sites where SEE has been demonstrated to remove the more volatile hydrocarbons in the field (BERC, 1995; USEPA, 1995).

The second laboratory test for leachable hydrocarbons, described in Appendix C of this Work Plan, specifically evaluated the potential for SEE to remove the more mobile components of the waste oil via steam distillation. The leachability of the hydrocarbons remaining in the soil after the application of steam was also evaluated through this test. The volatile components including benzene, toluene, ethylbenzene, xylenes, and total petroleum hydrocarbons as gasoline were removed by steaming of the soil during the laboratory test.

The laboratory treatability tests realistically simulate a single removal mechanism: steam distillation. However, steam distillation is only one of several mechanisms by which SEE can remove hydrocarbons from the subsurface. Other mechanisms include mobilization of free phase hydrocarbons as a bulk liquid with increased temperatures and pressure gradients in the subsurface. Field testing is necessary to evaluate these multiple removal mechanisms.

The first field test planned is a three-well treatability test run for a period of 30 days. The second field test planned is a 15-well pilot-scale demonstration run for an additional 180 days. The 15-well pilot-scale test will follow the general procedures described in this Work Plan. However, data obtained from the three-well treatability test will be used to improve the design. A detailed description of the 15-well pilot-scale test will be presented in a work plan prepared after data analysis and interpretation of information gained during the three-well treatability test. If changes to the activities described in this Work Plan are required, they will be documented in work plan addenda using the procedures described in Section 11 of the Contractor's Quality Control Plan (CQCP, Appendix D).

The three-well treatability test will determine if Site 13 soils are appropriate to propagate a sufficient steam zone and evaluate the upward mobilization of free phase hydrocarbons to the top of the water table by the application of steam at Site 13. Removal of hydrocarbons by steam distillation under field conditions will also be tested. The results will be used to decide if it is appropriate to proceed to the 15-well pilot-scale test, and if so, to develop designs and operation guidelines for the 15-well pilot-scale test. A prototype single injection and extraction well and actively cooled surface containment system will also be tested during the three-well treatability study. The goal of the 15-well pilot-scale test is to evaluate the applicability of SEE for cleanup of all of Site 13.

While initial laboratory testing indicates that SEE is not capable of removing all of the hydrocarbons from the subsurface at Site 13, the tests indicate that the more mobile hydrocarbons are removed by the application of steam. Removal of these hydrocarbons may result in a significant reduction in risk. Groundwater quality may also be protected if implementation of SEE leaves only the relatively insoluble and immobile hydrocarbons in the subsurface. The three-well treatability test will also provide data to characterize this potential reduction in risk.

If the results of the pilot-scale treatability study demonstrate that SEE can significantly reduce the risk to groundwater posed by the subsurface hydrocarbons, the results would then be used in an Engineering Evaluation and Cost Analysis (EE/CA) or Feasibility Study (FS) to select a remedial technology for all of Site 13. If SEE were selected as the remedial technology for the entire site, the results of the treatability study would also be used to develop designs and operating guidelines for the full-scale implementation of SEE.

1.1 OBJECTIVES

The overall objective of this treatability study is to ascertain the viability of the SEE process as a cost-effective in situ remedial method for restoration of soils and groundwater containing hydrocarbons at Site 13. As described in this Work Plan, the treatability study is composed of the following components and objectives.

- <u>Laboratory treatability testing</u> to determine the rates and extent of hydrocarbon removal by SEE as well as the leachability of hydrocarbons remaining in the soil after the application of steam. This portion of the pilot-scale treatability study has been completed.
- A three-well treatability test to quantify the in situ hydraulic parameters of the waste bearing zone, assess the performance of the prototype injection/extraction well design, assess the performance of the actively cooled surface containment system, determine if Site 13 soils are suitable to propagate a sufficient steam zone, measure the ability of SEE to mobilize free phase hydrocarbons from the waste bearing zone to the top of the water table, determine the rate and extent of hydrocarbon removal under field conditions, develop robust operational designs and procedures for the above ground treatment equipment, and refine the sizing requirements for treatment equipment to be used for the 15-well pilot-scale test; and
- <u>A 15-well pilot-scale test</u> to provide a comprehensive assessment of the overall technical feasibility of the SEE process to restore Site 13 and identify design improvements needed for full-scale implementation.

The above tests will be implemented sequentially to achieve the overall objective.

1.2 BACKGROUND OF SEE PROCESS

SEE was developed for environmental restoration applications in the late 1980s by engineering scientists from the University of California at Berkeley (UCB) (Hunt, Sitar and Udell, 1988; Udell, and Stewart, 1989; and Udell, et al, 1991). While steam injection for enhanced oil recovery has been practiced for decades by the oil industry (Mandl and Volek, 1969; Volek and Pryor, 1972; Konopnicki et al, 1979), additional thermodynamic features of the process were identified and exploited in the UCB work to make the process amenable to the restoration of sites contaminated with volatile and semi-volatile liquid contaminants found above and below the water table, as well as non-volatile compounds in the aqueous phase (Udell, et al, 1991; Udell and Stewart, 1992; and Udell, Sitar, and Stewart, 1995).

The SEE process removes hydrocarbons from the soil by injecting steam to volatilize hydrocarbons present in the subsurface and displace mobile liquids ahead of the advancing steam zone. Before steam break-through at the extraction wells, displaced liquids are pumped from the extraction wells. Once the steam zone reaches the extraction wells, hot vapors which contain the volatilized hydrocarbons are captured, condensed, and treated to remove liquid hydrocarbons for recycling and to process vapors and water before discharge.

Three field demonstrations of SEE have been completed. The first such demonstration was conducted in 1988 at a solvent recycling facility in San Jose, California (Udell, and Stewart, 1989). The second demonstration was conducted on a full-scale at The Lawrence Livermore National Laboratory (LLNL) in 1993 (Newmark ed., 1994; Udell, 1995; EPA, 1995). Nearly 8,000 gallons of gasoline were removed from the subsurface, including significant volumes from deep zones 25 feet below the water table. The remediation was conducted over a period of 6 months. This site is not expected to require further remedial work. The third demonstration was a pilot test at NAS Lemoore in 1994 (Udell and Itamura, 1995). Over 78,300 gallons of less volatile JP-5 was removed from the subsurface over a period of 3 months. JP-5 soil concentrations dropped from values over 50,000 milligrams per kilogram (mg/kg) to below 10 mg/kg at the location of the water table. Other steam injection projects have been completed or are in progress.

Steam has been applied to the removal of diesel at the Rainbow Disposal transfer yard in Huntington Beach, California (EPA, 1995) with lesser success due to inadequate injection rate and subsurface temperature monitoring.

1.3 REMEDIAL ACTION DECISION PROCESS

The results of the treatability study described in this work plan will be used to evaluate the feasibility of using steam enhanced extraction to remediate hydrocarbon containing soils at Site 13. The technical feasibility of steam enhanced extraction depends on many factors. These factors include the nature of the hydrocarbon residual at the site, the permeability of the subsurface, and the site closure requirements.

As the treatability study progresses, more information will become available on the factors that influence the feasibility of steam enhanced extraction. Therefore several decision points have been built into the study to allow the feasibility of steam enhanced extraction to be assessed as the study progresses. These decision points are indicated in Figure 1-1.

The initial characterization of Site 13, described in Section 4 of this Work Plan, indicated that the hydrocarbons present at Site 13 are less volatile than any yet subjected to treatability studies for steam enhanced extraction. Therefore BERC included in the June 30, 1995 draft work plan an initial laboratory treatability study for total hydrocarbons to estimate that fraction of the mass of hydrocarbons subject to removal by steam volatilization. The results of that treatability test, described in Appendix B, indicated that the application of steam did not remove the bulk of the mass of the total hydrocarbons from the soil tested, but that the more volatile hydrocarbons were removed by steam distillation. The volatile fraction normally includes benzene, a known carcinogen, and other hydrocarbons linked to health risks (toluene, ethylbenzene, and xylenes).

After reviewing the results of the laboratory treatability test for total hydrocarbons, the BCT (BRAC Cleanup Team) agreed that a second laboratory treatability test would be conducted to quantify the potential of steam enhanced extraction to remove the volatile hydrocarbon fractions; this second test is referred to as the laboratory treatability test for leachable hydrocarbons. The results of this second laboratory test, summarized in Appendix C, demonstrated that steam enhanced extraction could remove nearly all traces of the volatile compounds of most interest, benzene, toluene, ethylbenzene, and three closely related xylenes. The BCT will consider the results of the laboratory treatability test for leachable hydrocarbons, this Work Plan, possible site closure requirements, and the applicability of SEE to a previous JP5 spill in the northern portion of Site 13 before the Navy authorizes BERC to proceed with implementation of the three-well treatability test described in this Work Plan.

The three-well treatability test would evaluate the potential of steam enhanced extraction to remove volatile and free phase hydrocarbons from the soil at Site 13. The Navy, in consultation with the BCT, would review the results of the three-well test before authorizing implementation of the 15-well pilot-scale test. The 15-well pilot-scale test is intended to demonstrate that steam enhanced extraction could satisfy site closure requirements

1.4 PARTNERSHIP AGREEMENT

On August 24, 1994, the U.S. Navy and UCB entered into a partnership that provides the framework for exploring the application of innovative environmental restoration technologies developed by UCB, LLNL and the Lawrence Berkeley National Laboratory (LBNL), to Installation Restoration (IR) sites located within NAS Alameda boundaries. As part of the partnership agreement, UCB established the Berkeley Environmental Restoration Center (BERC) as a coordination office to administer the contract for UCB. This partnership is governed by Contract No. N62474-94-D-7430.

Delivery Order Number 003 (DO3) funds the demonstration of the SEE technology at Site 13 for the removal of contaminants from the soils and groundwater. UCB shall perform the following tasks in order to accomplish this objective:

- 1) Prepare a work plan including a site specific health and safety plan and a contractor Quality Assurance/Quality Control Plan to install treatability test wells.
- 2) Install treatability test wells to determine if the characteristics of the site and hydrocarbons favor further application of the SEE technology in a pilot-scale process by conducting hydraulic characterization of the pilot area and a steam injectivity test. Prepare a letter report summarizing the treatability test results.
- 3) Prepare a pilot-scale treatability design and work plan after data analysis and interpretation of information gained from the installation and operation of the treatability test wells.
- 4) Implement the pilot-scale SEE system in accordance with the approved work plan.
- 5) Operate the pilot-scale SEE system for 60 calendar days or until recovery rates decrease to low values indicating complete cleanup.
- 6) Prepare a pilot-scale treatability report for the SEE technology.

This Work Plan is written in response to the requirements of task one and describes tasks two through six.

1.5 RELATED DOCUMENTS

BERC has developed program-level documents to describe procedures to be followed on projects implemented under the partnership agreement. These include the:

- Health and Safety Plan, Volumes I and II;
- Contractor Quality Control Program Plan;
- Standard Operating Procedures; and
- Standard Quality Procedures.

Work at Site 13 will be conducted in accordance with the general procedures described in these program level documents and as more specifically described in this Work Plan. The program-level documents will be updated as required. The most recent version of each document is maintained in the BERC office and will be maintained at Site 13 during field operations.

1.6 ORGANIZATION OF WORK PLAN

The organization of this Work Plan is as follows:

- Section 1 of this work plan presents an overview of the pilot-scale treatability study to be performed at Site 13, as well as the contracting mechanisms that authorize the work and related documents that need to be referred to during implementation of the study.
- Section 2 includes a brief background of NAS Alameda and Site 13 with a discussion of previous investigations.
- Section 3 includes a description of the site hydrogeology.
- Section 4 includes a discussion of soil and groundwater quality.
- Section 5 discusses probable exposure pathways.
- Section 6 identifies data needs for the treatability study.
- Section 7 presents a conceptual design of the three-well treatability test including the steam injection and monitoring system as well as the treatment equipment that will be used for the liquid and vapor effluent streams from the system. An operational plan, describing how the three-well treatability test will be implemented and monitored is also provided in this section with a description of the criteria that will be used to assess the performance of SEE at removing hydrocarbons from the soil at Site 13 and to make a decision regarding proceeding to the 15-well pilot-scale test.
- Section 8 presents the implementation plan, including an implementation schedule.
- Section 9 describes the reporting that will be required for the treatability study.

UCB's response to comments received on the previous draft version of this Work Plan are included in Appendix A. Detailed results of the laboratory treatability test for total hydrocarbons are included in Appendix B and detailed results of the laboratory treatability test for leachable hydrocarbons are included in Appendix C. Appendix D includes the CQCP; Appendix E contains the sampling and analysis plan for the laboratory treatability tests. Appendix F presents the sampling and analysis plan for the three-well treatability test. Appendix G contains the results of a simulation performed to predict the performance of the steam injection/extraction system. The Site Health and Safety Plan (SHSP) is included in Appendix H and the Environmental Protection Plan is included in Appendix I; supplemental information is included in Appendix J. This information includes a technical article regarding SEE titled An Analysis from Heterogeneous Media Using Cyclic Steam Injection and prepared by Michael T. Itamura and Kent S. Udell of UCB.

2. BACKGROUND

2.1 NAS ALAMEDA DESCRIPTION

NAS Alameda is located on the western end of Alameda Island. The base, rectangular in shape, is approximately 2 miles long and 1 mile wide, and occupies 2,634 acres. Approximately 1,526 acres of NAS Alameda are land and 1,108 acres are bay.

Much of the land now occupied by NAS Alameda was once covered by the waters of San Francisco Bay or was tidal flats. Much of the base was gradually filled using hydraulically placed

dredge spoils from the surrounding San Francisco Bay, the Seaplane Lagoon at NAS Alameda, and the Oakland Channel.

The Army acquired the NAS Alameda site from the city of Alameda in 1930 and began construction activities in 1931. The Navy acquired title to the land from the Army in 1936 and began building the air station in response to the military buildup in Europe prior to World War II. After the 1941 entry of the United States into the war, more land was acquired adjacent to the air station. Following the end of the war, NAS Alameda returned to its original primary mission of providing facilities and support for fleet aviation activities.

2.2 SITE 13 DESCRIPTION

Site 13 consists of approximately 30 acres located in the southeast corner of NAS Alameda (Figure 2-1). This site is the former location of the Pacific Coast Oil Works refinery, which operated between 1879 and 1903. Refinery wastes and asphaltene residues were dumped at the site during the 24-year history of the refinery. The refinery consisted of pump and lubricating houses, stills, two laboratories and agitators, as well as approximately 19 above-ground iron oil storage tanks, six underground iron storage tanks, and a storage area containing drums of oil.

The section of Site 13 that is bordered by Avenues K and L and 9th and 11th Streets (Figure 2-2) is the location where the treatability study will be implemented, because this is the area where the highest concentrations of refinery wastes have been identified. The sections of the Pacific Coast Refinery that were located on that section of Site 13 include an oil storage area, a lubricating building, bleaching tanks, and several large iron oil tanks (PRC and MW, 1993b).

The location of the Pacific Coast Refinery was originally bound on the north by what is now K Avenue, on the east by Central Avenue, and to the south and west by the historical bay boundary. The historical bay boundary is shown on Figure 2-3 (PRC and MW 1993b). At the time of the refinery operation, the edge of the bay extended from the intersection of 9th Street and Avenue K, south along 9th Street 250 feet, and to the southeast where it crossed Avenue L approximately 300 feet east of 9th Street. The south west part of Site 13 was originally bay that was filled between 1942 and 1946.

The area once occupied by the refinery was later surfaced by the U.S. Navy. Sometime in the 1940s, a surface rupture occurred as a result of vapor pressure buildup from underground hydrocarbons and refinery wastes. To remove contaminated soil and reduce the risk of future rupture, the U.S. Navy excavated an area of approximately 30 by 30 feet (depth not recorded), and a concrete slab was placed in the bottom of the excavation which was then backfilled and resurfaced (PRC and MW, 1995a). The location of the removal was not available in the information reviewed.

Several naval facilities now exist on the site of the former oil refinery (Figure 2-2). A former on-base annex service station, Building 547 (Site 7C), is located in the northeast corner of the former oil refinery area. In the northwest corner is a hazardous waste storage yard (Site 19), which is currently in operation. A missile rework facility is housed in Building 530 (Site 10B), which is located in the southern portion of the former oil refinery area. The CANS C-2 Area (Site 16), a storage area for large shipping containers containing paints, solvents, acids, bases, and transformers containing polychlorinated biphenyls (PCBs) is located immediately to the south of Site 13.

During a previous removal action, approximately 104 cubic yards of soil exhibiting a low pH and containing high lead concentrations was removed from the area around Boring B-7 (Figure 2-3). Approximately another 50 cubic yards was expected to be removed after September 1994 however,

the removal report was not available for review. Subsequent reports indicate that the removal action took place. For this removal action, soil containing lead at concentrations greater than 100 mg/kg were removed from the southern portion of Site 13 (PRC and MW, 1993a). The excavation area is shown on Figure 2-7.

In February 1991, a JP-5 release occurred on the east side of Building 397 (Figure 2-2), a jet engine test cell. Following a period of heavy rains, several storm drain manholes overflowed, resulting in an accumulation of free product; twelve manholes in the area were found to contain floating product. The storm drain lines south of Building 397 were reportedly extensively damaged during the 1989 Loma Prieta earthquake and groundwater in the area may have been impacted by JP-5 leaking from the damaged storm sewer lines (PRC and MW, 1993b).

2.3 PREVIOUS INVESTIGATIONS

Five site investigations were conducted at Site 13 in 1989, 1990, 1991, and 1994. Soil borings and groundwater monitoring wells were installed throughout all of Site 13 as part of these investigations. The location of each boring and groundwater monitoring well installed within or adjacent to the block bound by Avenues K and L and 9th and 11th Streets is shown on Figure 2-3 along with the location of the four borings drilled by UCB for collection of soil samples for the laboratory treatability tests. In addition, the location of two monitoring wells observed in the field are shown; a reference documenting the installation of these wells has not been identified. The previous investigations are described as follows.

In 1989, Harding Lawson drilled and took soil samples from three borings (B-1 to B-3) to investigate the nature of petroleum hydrocarbons that were detected during the planned construction of the Intermediate Maintenance Facility. Upon detection of total petroleum hydrocarbons as JP-5 (TPHjp5) concentrations as high as 8600 mg/kg in some soil samples, an additional 15 soil borings (B-4 to B-18) were drilled. Soil Boring B-14 was converted to Monitoring Well MW-1 (HLA, 1989).

In 1990, Canonie performed an investigation at Site-13 to determine if chemicals from the former refinery were leaching into the groundwater. Three groundwater monitoring wells (MWOR-1 through MWOR-3) and seven soil borings (Bor-8, Bor-9, Bor-10, Bor-11, Bor-13, Bor-14, and Bor-19) were installed (Canonie, 1990).

In 1991 and 1992, PRC Environmental Management and J.M. Montgomery Consulting Engineers investigated the area surrounding Boring B-7 (installed in 1989 by Harding Lawson) to evaluate the extent of the low pH and elevated concentrations of lead identified in soil samples from this boring. Two groundwater monitoring wells (M-IMF-01 and M-IMF-02) and eleven soil borings (B-IMF-01 to B-IMF-11) were all drilled within 50 feet of Boring B-7 (PRC and JMCC, 1992; PRC and MW, 1993a).

In March and April 1994, PRC conducted a Site Characterization and Analysis Penetrometer System (SCAPS) project to evaluate the extent of refinery wastes at Site 13. The SCAPS project included the advancement of 26 SCAPS push holes (ALA13P01 through ALA13P23, ALA13P25, ALA13P26, and ALA13P37) and seven hollow-stem auger borings (ALA13PB38 through ALA13PB43 and ALA13PB45) (PRC, 1994).

In 1994, PRC conducted additional investigation to further characterize the extent of soil and groundwater contamination. As part of this investigation, Monitoring Wells M13-06 and M13-07 were installed and three GeoProbe investigations (13GB004 through 13GB006) were carried out just to the east of 9th Street (PRC and MW, 1995a).

3. SITE HYDROGEOLOGY

The geologic units encountered at Site 13 consist of artificial fill, Bay Mud, and the Merritt Sand. The artificial fill and Merritt Sand comprise the first and second water bearing zones of the shallow aquifer at NAS Alameda (PRC and MW, 1995b). Where present, the Bay Mud separates the two water bearing zones. However the Bay Mud is not continuous beneath Site 13.

Site 13 is immediately underlain by artificial fill to depths of 5 to 12 feet bgs; this unit generally consists of sand and silty sand. Where present, Bay Mud consisting of dark gray silty clay is typically encountered at 9 to 12 feet bgs. The Merritt Sand underlies the Bay Mud and directly underlies the artificial fill where the Bay Mud is absent. The depth to the top of the Merritt Sand ranges from five to 12 feet bgs. The cross section provided in Figure 3-1, constructed from borings installed as part of the SCAPS project, illustrates the relationship of these geologic units immediately to the south of the planned treatment area for the SEE Pilot-Scale Treatability Study.

The depth to groundwater at Site 13 ranges from 4 to 7.5 feet bgs (PRC and MW, 1995b). Local groundwater directions and gradients vary. However, groundwater at Site 13 generally flows to the southwest with an average hydraulic gradient of 0.001 to 0.003 feet per foot. Hydraulic conductivities measured on soil samples from Site 7C, located adjacent to Site 13, were 3.0E-07 centimeter per second (cm/sec) for a sample of Merritt Sand from a depth of 10.5 feet and 1.0E-03 cm/sec for a sample of hydraulic fill from a depth of 2 feet. The hydraulic conductivity for the Merritt Sand is questionable because the value reported is typical of the hydraulic conductivity for a clay which would typically have a lower hydraulic conductivity than a sandy material.

4. SOIL AND GROUNDWATER QUALITY

4.1 SOIL QUALITY

This section presents a summary of the soil quality at Site 13 based on the previous investigations discussed in Section 2.3. The locations of all boring and monitoring wells referenced are shown on Figure 2-3.

During the 1989 investigation, soil and water samples were analyzed for total petroleum hydrocarbons (TPH); semivolatile organic compounds (SVOCs); oil and grease, benzene, toluene, ethylbenze, and xylenes (BTEX); and pH. Petroleum hydrocarbons were identified in soil samples from 15 of the 18 borings. Borings B-9 and B-10, located on the far west side of Site 13, did not contain detectable hydrocarbons. The other boring where hydrocarbons were not found was Boring B-2 located approximately 80 feet south west of Building 397. In the soil sample from 4.5 to 5 feet bgs in Boring B-7 lead was identified at 13,000 mg/kg, total petroleum hydrocarbons as gasoline (TPHg) was identified at 16,000 mg/kg, total petroleum hydrocarbons as diesel (TPHd) was identified at 76,000 mg/kg, and oil and grease was identified at 120,000 mg/kg; this soil sample also had a pH of 1.6. None of the other soil samples taken from the other borings had a pH that was less than 5.5. The next highest lead level found in the soil samples was 140 mg/kg for a soil sample taken at Boring B-8 (HLA, 1989).

During the 1991 and 1992 investigation to evaluate the extent of lead and low pH soil identified in the soil sample from Boring B-7, soil samples from 11 soil borings and Monitoring Well M-IMF-02 were analyzed for pH and lead. Of the 20 soil samples from within ten feet of B-7 (from B-IMF-09 through B-IMF-11 and M-IMF-02), seven had a pH of less than 5.5 and only thirteen had a pH of greater than 5.5. Of the 47 soil samples taken between 10 and 50 feet from B-7, none had a pH of less than 4 and 38 had a pH higher than 7. Six of the 35 soil samples analyzed had lead concentrations greater than 100 mg/kg. The highest lead level detected was 1980

mg/kg for a soil sample taken at 3 feet at Boring B-IMF-10. Soil samples were also taken using a hand auger to determine if the pH readings seen at Boring B-7 in the 1989 Harding Lawson investigation were accurate. A soil pH of 0.7 was found in soil samples taken 4 feet bgs next to the location of Boring B-7. During this investigation, two soil samples, one from eight feet in Boring B-IMF-01 and another from four feet in Boring B-IMF-06, were analyzed for base/neutral/acid semivolatile organic compounds and none were identified (PRC and JMMC, 1992).

In 1994 a removal action was conducted to excavate soils with lead levels greater than 100 mg/kg. During the removal action, field screening for lead concentrations and the pH of soil samples were used to determine the extent of the excavation (PRC and MW, 1993a). The limits of excavation were not available from the literature reviewed.

During the 1990 Canonie investigation, soil samples were analyzed for total recoverable petroleum hydrocarbons (TRPH), volatile organic compounds (VOCs), SVOCs, metals, pesticides, and pH. With the exception of soil samples from Borings Bor-9 and Bor-19, the TRPH concentrations identified were all less than 100 mg/kg. Boring Bor-9 is located 60 feet southwest of Monitoring Well MW-1. Soil Boring B-19 is located at the intersection of Avenue L and 11th Street at the southeast corner of Site 13. TRPH was identified at 4,360 mg/kg in the soil sample from 6.5 feet in Boring Bor-9 and at 3,600 mg/kg in the soil sample from 11 feet in Boring Bor-19. VOCs identified in the soil at concentrations greater than 1 mg/kg were methylene chloride, benzene, ethylbenzene, toluene, and xylenes. SVOCs detected at concentrations greater than 10 mg/kg included Di-n-butylnapthalate and 2-methylnapthalene. Pesticides were detected in concentrations less than 0.035 mg/kg and were identified in soil samples from Borings Bor-8 and Bor-9. The pH was greater that 5.5 in all of the 14 soil samples analyzed for pH (Canonie, 1990).

During the 1994 PRC investigation, three soil samples from Monitoring Well M13-06 were analyzed. VOCs and TPH were not identified in soil samples from this boring (PRC and MW, 1995a).

During the 1994 SCAPS project, petroleum hydrocarbon concentrations in the soil were measured using an in situ fluorometer. The results of these measurements were validated by traditional laboratory analysis of a total of 45 soil samples from locations ALA13-PB38 through ALA13-PB43 and ALA13-PB45 for TRPH, TPHd, TPHg, TPHjp5, and total petroleum hydrocarbons as motor oil (TPHmo) and pH. The pH of the soil samples ranged from 1.1 to 9.3. The locations of soil samples with a pH lower than 5.5 are indicated in Figure 2-9. The soil sample from 7 to 7.5 feet bgs in Boring ALA13-PB41 had a pH of 1.1. The highest concentrations of TPHd and lead were also identified in this soil sample. The concentrations were 170,000 mg/kg and 413 mg/kg, respectively.

In the zero-to five-foot depth, soil pH values that were less than 5.5 were identified only in soil samples from Boring B-IMF-06 to the north of Boring B-7. In the 5 to 10 foot depth, low pH soil was only identified in soil samples from the vicinity of Boring B-7 and at SCAPS Boring ALA13-PB41 (Figure 4-1). The soil around Boring B-7 has been removed.

Hydrocarbons in the form of TPH, TRPH, or oil and grease are mostly concentrated in the central and eastern sections of the site. Figure 4-2 illustrates the distribution of hydrocarbons in soil samples from the zero-to five-foot depth. Hydrocarbon concentrations greater than 10,000 mg/kg were identified in soil samples from within five feet of the ground surface at Monitoring Well MW-1 (Boring B-14), near the southeastern corner of Building 39, and in the vicinity of Boring B-7. Figure 4-3 shows the distribution of hydrocarbons in soil samples from the five to ten foot depth; the levels above 10,000 mg/kg were also clustered around B-7 and B-14. Areas of hydrocarbon levels between 1,000 and 10,000 mg/kg extend several hundred feet between B-7 and B-14. Figure 4-4 shows the distribution of hydrocarbons in soil samples from the 10 to 15 foot depth.

At this depth, there were no soil samples with concentrations greater than 10,000 mg/kg. The region with hydrocarbon concentrations between 1,000 and 10,000 mg/kg extends from north centrally located SCAPS Boring ALA13-PB45 to Boring Bor-19, located in the south east part of Site 13. The distribution of hydrocarbons in soil samples from the 15 to 20 foot depth is illustrated on Figure 4-5. The only soil sample from this depth that had hydrocarbon concentrations greater than 1,000 mg/kg was from Boring B14.

The distribution of lead identified in soil samples from the zero-to five-foot depth is illustrated on Figure 4-6. Lead concentrations greater than 100 mg/kg were identified in Borings B-7 and B-8. Lead concentrations were greatly reduced in the five-to ten-foot depth and lead was not identified at concentrations greater than 100 mg/kg in any soil samples from depths greater that 10 feet.

In summary, TPHg, TPHd, oil and grease, VOCs, SVOCs, lead, and some pesticides have been identified in soil samples from Site 13. The highest hydrocarbon concentrations identified were 120,000 mg/kg of oil and grease and 76,000 mg/kg of TPHd. Hydrocarbons were identified at the greatest depth in soil samples from Boring ALA13-P13; this location was selected for implementation of the SEE Pilot-Scale Treatability Study.

Soil from the vicinity of Boring B-7 exhibited low pH values and high lead concentrations. This soil was removed during a removal action. Soil from the vicinity of Boring ALA13-PB41 exhibited a low pH and this soil remains in place.

4.2 GROUNDWATER QUALITY

In the 1989 Harding Lawson investigation, groundwater from Monitoring Well MW-1 (Boring B-14) was analyzed for VOCs, TPHd, oil and grease, base/neutral/acid compounds (BNAs), and dissolved metals. Benzene was identified at a concentration of 0.44 milligram per liter (mg/l) and no other VOCs or BNAs were identified at a concentration greater than 0.005 mg/l. Lead was identified at 0.05 mg/l; TPHg was identified at 11 mg/l; and oil and grease was identified at 60 mg/l.

During the 1991 and 1992 PRC investigations, groundwater samples taken from the borings closest to Boring B-7 had pHs of 0.9, 2.8, 6.7, and 3.0. Lead was identified in the groundwater at concentrations ranging from 0.0015 to 1.77 mg/l in water samples taken from these borings. The lowest pH and the highest dissolved lead levels were found in groundwater from Boring B-IMF-09. This soil boring was located approximately 8 feet north of Boring B-7.

The pH of groundwater samples from Monitoring Wells MWOR-1 through MWOR-3 (sampled in 1990) ranged from 6.8 to 7.8. Methylene chloride was identified in the groundwater samples from MWOR-1 and MWOR-3 and DDT was identified in the groundwater sample from Monitoring Well MWOR-1.

During the 1994 SCAPS investigation, water samples from Borings ALA13-PB40, ALA13-PB43, and ALA13-PB45 were analyzed for TPHd, TPHg, TPHjp5, TPHmo, pH, and metals. The TPH levels were all less than 0.1 mg/l and the pH levels were all between 5.6 and 6. Lead levels were equal or less than 0.001 mg/l.

During the 1994 site investigation, the groundwater from the GeoProbe investigations was analyzed for VOCs, TPHd, and TPHg. These compounds were not identified in groundwater samples from GeoProbe Well 13GB005. Water samples collected from Monitoring Wells M13-06 and M13-07 as well as four of the previously installed Monitoring Wells (MW-1 and MWOR-1 through MWOR-3) were analyzed for VOCs, SVOCs, TPHd, TPHg, metals, general

chemicals, total organic carbon, and pesticides/PCBs. No VOCs, SVOCs, or pesticides were identified in any of the groundwater samples from the area of interest. The highest TPHd concentrations identified in any of the groundwater samples was 10 mg/l identified in the groundwater sample from Monitoring Well MW-1. TPHd was identified at 1.75 mg/l and 2.0 mg/l in the groundwater samples from Monitoring Well M13-06 and M13-07 but was not identified in groundwater samples from the other three wells. The groundwater sample from Monitoring Well M13-07 (located adjacent to the area of interest) also contained detectable levels of VOCs and phenols.

In summary, TPHg, TPHd, benzene, oil and grease, and lead have been identified in the groundwater at Site 13, primarily in the vicinity of Monitoring Well MW-1. Methylene chloride and DDT have also been identified in the groundwater. With the exception of groundwater samples obtained from the vicinity of Boring B-7 where a soil removal action was conducted, the pH of the groundwater at Site 13 generally varies from 5.6 to 7.8.

5. PROBABLE TRANSPORT PATHWAYS

Potential sources of soil and groundwater contamination at Site 13 include historical oil refinery operations and waste disposal as well as the JP-5 release on the east side of Building 397. The site is currently unpaved. Under existing conditions, exposure to contaminants present in the subsurface soil would not be expected unless the ground were disturbed. Petroleum hydrocarbons have been identified in the groundwater and compounds identified in the vadose zone soil could be transported to the groundwater with infiltration of water from the ground surface.

Under reuse of this site, future site occupants could potentially be exposed to the contaminants present through inhalation of compounds that could be volatilized to indoor or outdoor air. If soil were disturbed, exposure to the contaminants could also occur through direct contact with or ingestion of soil or groundwater. Ground disturbing activities could also produce particulates containing chemicals; individuals could be exposed to these particulates through direct contact, inhalation, and ingestion. Additional off-site exposures could occur if the particulates are deposited at nearby sites.

SEE would be expected to remove the more volatile components of the oily material which would eliminate exposure through inhalation of the volatile compounds. The components of the oily materials left in place after the application of SEE would be expected to have lower toxicity than the compounds that would be removed. This would reduce the risk associated with the remaining exposure pathways. Application of SEE would also be expected to reduce the leachability of the hydrocarbons remaining in place which would reduce the risk to groundwater.

6. TREATABILITY STUDY DATA NEEDS

Several types of information are needed to evaluate the effectiveness of SEE as a potential remediation method for Site 13. The activities described in this Work Plan are intended to provide the necessary information. The data needs for this project are listed below; Table 6-1 summarizes each data need and the Work Plan activity that is intended to fill the data need. Data needs for the implementation of SEE at Site 13 include:

• the suitability of Site 13 soils for propagation of a sufficient steam zone;

- an assessment of the ability of SEE to upwardly mobilize free phase hydrocarbons to the top of the water table.
- an assessment of the ability of SEE to remove hydrocarbons from the subsurface through steam distillation; and
- an assessment of the leachability of the hydrocarbons remaining in place after the application of steam.

7. CONCEPTUAL DESIGN OF PILOT-SCALE TREATABILITY STUDY

The implementation of SEE at Site 13 includes the following activities:

- Warming of the treatment zone with steam to allow mobilization of free product oil to the extraction interval of the wells where it will be pumped from the subsurface. During this process, the saturated zone is dewatered and residual oil is exposed to the injected steam which enhances volatilization and flow of the oil.
- Collection and recycling of recovered free phase hydrocarbons;
- Collection of condensate from extraction wells and from the ground surface;
- Collection of groundwater pumped from the injection/extraction wells;
- Treatment of the condensate and groundwater by carbon adsorption followed by discharge to the sanitary sewer; and
- Treatment of vapor emissions from the treatment system by thermal oxidation.

Fifty-percent designs and design principles for the three-well treatability test are discussed in this section. Detailed designs for this test will be prepared and included in bid documents distributed to potential subcontractors. Tasks required to implement the three-well test are described in Section 9.1, and sampling and analyses that will be conducted for the laboratory treatability tests and the three-well treatability test are described in Appendices E and F, respectively.

7.1 DESCRIPTION OF TREATABILITY SYSTEM

Implementation of the three-well treatability test at Site 13 will require the installation of a set of three wells for steam injection and withdrawal of vapors and fluids (injection/extraction wells); installation of the appropriate above-ground effluent treatment equipment; and installation of a surface containment system to capture condensable vapors created during steam injection. Base steam, compressed air, water, power, and wastewater disposal utilities are available adjacent to the site. Present utility locations are shown on Figure 7-1.

The injection/extraction wells will be installed in the vicinity of Boring ALA13-P13 (Figure 2-3) where hydrocarbons have been identified in the soil to a total depth of 17 feet. Planned well

locations are shown on Figure 7-2. Final determination of the placement of the wells, and the length and vertical placement of the screened intervals will be made after more detailed information regarding the vertical distribution of the hydrocarbons in the soil is collected as described in Section 1 of the Sampling and Analysis Plan for the Three-Well Treatability Test, Appendix F. The information obtained will be used to adjust the locations and screened intervals for the injection/extraction wells to better suit the implementation of the process. The final well locations will be selected in areas within the planned treatment zone where the hydrocarbons are identified at the greatest depths.

The application of SEE will include injection of steam to first mobilize the free product oil to the top of the water table by injection of steam from below. As temperature readings indicate that the lower zone is warmed sufficiently to volatilize hydrocarbons into the vadose zone, steam will also be injected to the vadose zone to prevent condensation of vapors prior to extraction at the ground surface or from extraction wells. During this operation, the treatment zone will be dewatered by mechanical pumping and steam displacement; groundwater that is displaced by the steam will be pumped from the injection/extraction wells. Once the subsurface reaches temperatures and pressures sufficient to mobilize free product, more groundwater will be pumped from the injection/extraction wells to create a groundwater gradient towards the injection/extraction wells to enhance the recovery of separate phase hydrocarbons. Free phase hydrocarbons will be pumped from the subsurface using injection/extraction wells that are not being used for injection of steam.

Once the free phase hydrocarbons mobilized by the application of steam have been removed, the primary mechanism for hydrocarbon removal will be steam distillation. During this phase of the test, the more volatile hydrocarbon fractions will be vaporized from the contaminated zone and removed with vapors rising through the contaminated zone from the underlying steam. The vapors will be withdrawn for treatment by applying a vacuum to the injection/extraction wells and the two surface containment systems that are being tested as part of the three-well treatability test. Contamination of the vadose zone during this phase of the test will be avoided by maintaining the vadose zone at elevated temperatures to prevent the condensation of vapors. All liquids and vapors produced during the three-well treatability test will be collected and treated using the effluent treatment system described in Section 7.6.

The three-well treatability test will be installed and operated for 30 days to support the decision of whether to proceed to the 15-well pilot-scale test and to generate data appropriate for sizing the pilot-scale system final design if the decision is made to proceed. The initial three wells will be located to become part of the pilot-scale pattern if initial results indicate SEE applicability to site cleanup.

7.2 PROPAGATION OF STEAM ZONE

As steam is injected into the subsurface, the steam zone propagates outward and upward in a shape determined by the permeability of the field. The minimum lateral radius of the zone is expected to be equal to the depth of steam injection for uniform vertical and horizontal permeability. The lateral radius would be greater if the horizontal permeability of the subsurface materials is significantly more than the vertical permeability. Thus, the minimum radius of the steam zone is expected to be 30 feet; the actual radius of the steam zone may be greater if the horizontal permeability of the soil is greater than the vertical permeability, which is typical of natural soil systems, or if the presence of tarry materials reduces the upward steam relative permeability. During operation, steam is injected to the region beneath the contaminated zone and is expected to rise upwards; this should prevent downward migration of contaminants during steam injection.

Propagation of the steam zone at Site 13 was modeled using M2NOTS-TOUGH2, a fully validated multiphase multicomponent simulator for porous media flow developed at LBNL and UCB. This

model provided temperature profiles as well as water and hydrocarbon saturation profiles for time intervals of one day, five days, 10 days, 22 days, 34 days, and 50 days. The results of the model are discussed in Appendix G. The model provided a preliminary evaluation of the propagation of the steam zone and movement of oil expected during implementation of the three-well treatability test.

The model was run using a vertical to horizontal permeability ratio of 1:10 with a horizontal permeability of 3 x 10⁻³ cm/sec. Given this assumption, steam injection into a single well is predicted to warm the soil within a 10-foot radius of the injection well by day 10. By day 34, the modeled temperatures within the treatment zone have stabilized. Figure 7-3 shows the temperature profile for day 34. These rough predictions were made using a steam injection rate of 240 pounds per hour into a single well.

7.3 AQUIFER DEWATERING

During the initial phases of the test to warm the treatment zone and mobilize free phase hydrocarbons, steam will be used to heat the contaminated zone for up to 10 days. Aquifer dewatering will be accomplished primarily by mechanical pumping from the injection/extraction wells to maintain a hydraulic gradient towards the injection/extraction wells. Assuming the hydraulic conductivities used for the modeling, a pumping rate of approximately 1 gallon per minute will be required to lower the water table by 1 foot at each injection/extraction well location. Depending if free phase hydrocarbons are mobilized, the water table may need to be lowered up to 10 feet. The pumping rates and water levels will be adjusted to maintain optimal recovery of the free phase hydrocarbons. It is assumed that pumping rates up to 10 gallons per minute may be required from each injection/extraction well. During this period, approximately one third to one half of a pore volume, or 20,000 gallons of groundwater, would be displaced by the injection of steam.

During the final phases of the test, when hydrocarbons are expected to be removed through steam distillation, aquifer dewatering will be accomplished through displacement by steam. The volume of water expected to be displaced is approximately equal to one pore volume within the treatment zone, or 58,000 gallons. Groundwater from outside of the treatment zone will also be drawn in by pumping from the injection/extraction wells.

Outside of the treatment zone, displaced groundwater may be pushed outward through displacement by steam. This may carry some contaminants outward. However, the extraction rates will be set to be greater than the steam injection rates (as water) and the rate of water displacement by steam zone growth; through use of these controls, outward movement is not expected to be significant. Regardless, groundwater monitoring described in Section 7.4 will be conducted to monitor the potential outward mobilization of contaminants from the treatment zone.

During these final stages of the test, it is essential that the contaminated zone is completely dewatered. Modeling described in Section 7.2 predicts that, with the exception of a small zone immediately around the injection well, the entire water-bearing zone within the treatment area will be dewatered by day 34 using steam.

The rate of water extraction from the pilot demonstration cannot be predicted without knowledge of the site permeability. However, at Lemoore, SEE was implemented for 90 days at an average water pumping rate of 13 gal/min. Using this pumping rate, approximately 500,000 gallons of water would be removed from Site 13 during the three-well treatability test which will be operated for approximately 30 days. Conservatively assuming the thickness of the aquifer and porosity to be at least 10 feet and 0.3 respectively, groundwater contamination 400 yards away would move less than nine feet toward the pilot demonstration.

7.4 STEAM INJECTION/EXTRACTION AND MONITORING SYSTEM

During the three-well treatability test, steam will be injected to the subsurface through injection/extraction wells. The design of the wells will allow simultaneous injection of steam and withdrawal of groundwater and free hydrocarbons from the same well. During operation of the test, the propagation of the steam zone will be measured by monitoring the temperature and resistivity of the subsurface materials as described below.

The injection/extraction wells for the three-well treatability test will be installed in the approximate locations shown on Figure 7-2; specific locations will be selected after cone penetrometer testing with laser induced fluorescence is completed as described in the Sampling Analysis Plan for the Three-Well Treatability Test, Appendix F of this Work Plan, to identify the area within the planned treatment area with the deepest and greatest hydrocarbon concentrations. The wells will be placed in this area in an equilateral triangle, spaced 35 feet apart to enhance the ability of SEE to remove free phase hydrocarbons.

Recent applications of SEE in similar situations showed the need for flexibility in the control of liquid pumping operations and steam injection locations which could not be achieved using separate injection and extraction wells. Thus, three single injection/extraction wells will be installed for the three-well treatability test to provide better flexibility in controlling liquid pumping and steam injection. The single well design to be tested at NAS Alameda is a significant improvement in these regards. Details of the well design are shown on Figure 7-4. The design includes two screened intervals; the uppermost interval will be screened in both the vadose zone and the water table with the bottom of the screened interval at a depth approximately equal to the bottom of the zone of contamination. The deeper screened interval will consist of a five-foot-long screen located beneath the contaminated zone. Both intervals may be used for steam injection and vacuum extraction. Liquids, including the free hydrocarbon phase, will be pumped from the upper screened interval using a pneumatic pump (Figure 7-4). Compressed air will be used to operate the pump. For greater precision in subsurface transport definition, the design will also allow for the insertion of a logging tool used to evaluate vertical gas flow rates, gas concentrations, and temperatures.

The two screened intervals will be separated by a five-foot-long blank section of casing. Two steel plates will be installed at the bottom of the blank interval to allow injection into each screened interval separately and minimize the transfer of heat between the two screened intervals. The annular space opposite of the blank casing will be sealed with bentonite to prevent steam injected into the deeper screened interval from preferentially migrating upwards through the annular space.

Fluids will be pumped from the injection/extraction wells using a pneumatic "ejector" pump, such as one manufactured by Franklin Research Company. The pump is diagrammed on Figure 7-5. Liquid fills the pump by gravity feed and is expelled through a check valve with compressed air. Once the liquid has been expelled, the compressed air is vented and the liquid again fills the lower tank module, allowing another pumping cycle to begin.

Sixteen temperature observation wells will also be installed in the locations shown on Figure 7-2. As shown on the figure, one temperature observation well will be installed within the annular space of each injection/extraction well. The remaining wells are located such that six are located equidistant around each injection/extraction well.

The design of the temperature observation wells is shown on Figure 7-6. The temperature observation wells installed within the annular space of the injection/extraction wells will be placed within the annular space as the injection/extraction well is constructed. At the remaining locations,

the wells will be installed using percussion insertion for reduction in cost, greater temperature sensitivity, and elimination of soil cuttings disposal. Subsurface temperatures are monitored by the placement of subsurface thermocouples. To allow for the possibility of continuous temperature logging, the fixed thermocouples will be attached to the outside of a bottom-sealed, 2-inch-diameter, 25-foot-long, schedule 40 carbon steel pipe, inserted into a boring and grouted in place. The thermocouples will be sealed in stainless steel sheaths, attached to 24 gauge, Teflon-coated wire, extending to above ground. The coded wires will extend 5 feet beyond ground level, be finished with compatible plugs for quick attachment to a thermocouple output display unit, and housed in a weather-proof enclosure.

Large increases in soil temperature caused by the injection of steam create substantial changes in soil resistivity. Electrical resistance tomography (ERT) will be used to map the subsurface progress of steam injection as a function of space and time. ERT measurements will be made using a combination of surface and downhole measurements to map the steam propagation. Seven electrode wells will be installed, each containing one strand with five regularly spaced electrodes. Between each pair of electrode wells, ten surface electrodes will be installed for a total of 60 surface electrodes. The planned electrode well locations are shown on Figure 7-2. A schematic of the electrode well design is given on Figure 7-7. Resistivity measurements will be made before, during, and after steam injection, and will be processed to generate two-dimensional vertically oriented resistivity tomographs.

Groundwater monitoring wells will also be installed outside of the treatment zone and monitored to detect outward migration of dissolved contaminants from the treatment zone. Planned locations for the groundwater monitoring wells are shown on Figure 7-2. The wells will be installed to monitor dissolved constituents as well as the presence of free phase hydrocarbons. The planned well design is shown on Figure 7-8.

One groundwater monitoring well will be located 15 feet radially outward from each injection/extraction well. Monitoring of groundwater levels, air pressures, groundwater quality, and free phase hydrocarbon thickness in these wells will allow monitoring of the outward migration of groundwater and contaminants from the treatment zone. A fourth groundwater monitoring well will be located 35 feet radially outward from the injection/extraction well located in the southwest portion of the treatment area; this is in the approximate downgradient direction from the planned treatment area. This groundwater monitoring well is located at the outside of the expected steam zone and should provide an evaluation of movement of groundwater and contaminants at the outer limits that would be affected by the injection of steam.

7.5 SURFACE CONTAINMENT SYSTEMS

Two surface containment designs (Figure 7-9) will also be installed and tested during the pilot-scale treatability study. The selection of the better of the two surface covering designs will be determined based on cost and performance during the three-well treatability test. The installation price of both systems will be comparable. The operation of the active system will be more expensive because it will require cooling from the sprinkler system and handling of the runoff. This higher operational cost may be offset by superior performance and greater control in the ability to recover vapors without clogging of the treatment equipment. The superior covering will be the design delivering acceptable performance for the lowest total cost.

The actively cooled and passive surface containment systems will each be 35 feet by 70 feet in dimension. They will be placed side by side and together they will cover the entire steam zone estimated by during operation of the three-well treatability test; the size and extent of the steam zone will be routinely monitored to keep the steam zone within the containment system. Its shape and

size can be controlled through control of steam injection rates and intervals along with vapor and groundwater pumping rates.

The design of the actively cooled surface containment system (Figure 7-10) will allow condensable vapors to flow to an upper metal barrier, fabricated from corrugated roofing material, where heat losses to the environment will allow condensation. Enhanced condensation will be achieved by active cooling of the exposed surface of the barrier with a spray of water applied with a water sprinkler system. The sprinkler heads will be mounted on half-inch PVC piping positioned near the crest of the surface covering. The condensed vapors will drain along the underside of the corrugated cover into a collection through.

Heat transfer analysis of the active surface covering including cooling from evaporation of the cooling water applied to the covering indicates that sufficient cooling is provided by evaporation alone to maintain a surface temperature of 40°C. The evaporation rate over the active cooling surface area should be 31 gallons per hour. To provide additional cooling capacity, sprinkler heads with 180° discharge patterns over a six-foot radius will be used. These will provide a collective flow rate of 50 gallons per hour.

The passive containment system (Figure 7-11) is simply a vapor barrier with soil placed on top for thermal insulation and protection. Beneath the vapor barrier, a 3-inch thick gravel layer will allow removal of vapors flowing up from the steamed soils through the application of a vacuum to the region. The recovered vapors will be routed through conveyance piping to the effluent treatment system described in Section 7.6.

Both surface containment systems will be keyed into the ground surface to minimize the introduction of atmospheric vapors when a vacuum is applied. Each system is also designed with a gutter to collect rainfall; the gutter is sized for the maximum 100-year rainfall. The gutter for the actively cooled containment system will also collect excess cooling water (maximum flow rate of 5 gallons per minute). This water is considered clean and will be recycled for cooling water reuse.

7.6 EFFLUENT TREATMENT SYSTEM

Implementation of SEE at Site 13 will produce two effluent streams requiring treatment. These include:

- hydrocarbons and groundwater pumped from the injection/extraction wells during groundwater sampling, aquifer testing, and operation of the SEE system; and
- condensed vapors and cooling water from the containment systems.

Liquid and vapor effluents are treated separately within the treatment system. The flow schematic of the above-ground processing equipment is shown on Figure 7-12. The planned lay out of the equipment is shown on Figure 7-13. Table 7-1 presents a list of the equipment that will be used for the treatment system. The three-well treatability test will require installation of most of the above-ground treatment equipment necessary for the pilot-scale implementation. The sizes stated in Table 7-1 are the estimated sizes required for the three-well treatability test.

The liquid effluent treatment system recovers and treats liquids from the injection/extraction wells and surface containment systems. This treatment system will also be used to treat liquids produced during groundwater sampling and aquifer testing. The liquids expected to comprise this effluent stream include water and free phase hydrocarbons. The chemical quality of water produced in these effluent streams is expected to be similar to the groundwater quality.

Liquid mixtures from the surface containment systems are first pumped to an above-ground oil water separator located near the treatment area and separated into surface vessels (Figure 7-13). The volumes of water and free phase hydrocarbons are measured and these fluids are then pumped together to oil-water separator #2 with the liquid effluent from the injection/extraction wells as indicated on the flow schematic provided on Figure 7-12. Measurement of the volumes of recovered free phase hydrocarbons and water in the surface separation vessels prior to discharge to the effluent treatment system allows a separate assessment of the volumes of these materials that are recovered through volatilization in the subsurface.

The effluent vapor treatment system recovers and treats vapors from the surface containment systems and the injection/extraction wells. These effluent streams will be at elevated temperatures and are expected to contain hydrocarbons at near saturation levels. Figure 7-12 shows the flow schematic for this effluent stream. Liquid is cooled and removed from the vapor mixture in a liquid trap. Separated liquid is then pumped to oil-water separator #1.

The gas stream from the vapor effluent goes to an air-cooled heat exchanger where steam and the hydrocarbon vapor are condensed. The gas-liquid mixture then enters a vapor-liquid separator. Upon exiting the vapor-liquid separator, the liquid phase is pumped to oil/water separator #1, and the noncondensable air is removed with a vacuum blower to be treated by a thermal oxidizer before its release to the atmosphere. Thermal oxidation is considered appropriate for this effluent stream because the temperature of the gas stream after the compression process within the vacuum blower may exceed the temperature limit of the carbon canisters and hydrocarbon concentrations in this gas stream are expected to be near saturation due to the elevated temperatures.

Separated oil from oil-water separators #1 and #2 are pumped to an oil storage tank for subsequent recycling. Vapors from the oil-water separator and the oil storage tank are treated by carbon adsorption to remove hydrocarbons before release to the atmosphere. Carbon adsorption is considered a cost-effective treatment method for these vapors because the low volatility hydrocarbons that will be recovered are not expected to produce large quantities of vapors.

Water from the oil-water separators is pumped through carbon canisters to reduce the concentrations of dissolved hydrocarbons. Rainwater from the surface containment systems and cooling water from the actively cooled containment system are also pumped directly to these canisters. Carbon adsorption is considered an appropriate treatment method for these liquid waste streams because the water will be at ambient temperatures and is expected to contain low concentrations of the contaminants recovered.

The carbon treatment systems for the effluent gas stream and the effluent water stream will each consist of two carbon canisters in series. The maximum treatment flow rate for the gas stream is 180 scf/min and the maximum treatment flow rate for the liquid stream is 50 gal/min. During operation of the three-well treatability test, sampling will be performed after the first canister in each system to provide early detection of breakthrough. Once sampling results indicate that the effluent quality from this canister exceeds acceptable discharge limits, the first canister will be taken off-line, sent for regeneration, and replaced with the second canister. A new canister would then be installed to replace the second canister. This rotation of carbon canisters will prevent the possibility of an accidental release of vapors to the atmosphere or contaminated liquids to the sewer system. A spare carbon canister for each system will be available to allow prompt exchange of the carbon canisters when breakthrough is identified.

The pH of the effluent water from the carbons canisters is metered and the effluent is treated, if necessary, before discharge to the NAS Alameda waste water collection system under a permit from the East Bay Municipal Utility District (EBMUD). The NAS Alameda point of contact for discharge to this system is Randy Cate. The EBMUD contact is Robert Newman. Discharge limitations for the effluent will be established in the discharge permit.

7.7 OPERATIONAL PLAN

The three-well treatability test will be performed in three phases. The first phase will be conducted to bring the entire treatment zone to steam temperatures as quickly as possible while controlling the movement of displaced fluids and vapors. During this phase, steam will be injected from below the zone containing oily materials to raise the temperature of the oily materials and promote the upward mobilization of free phase hydrocarbons to the top of the water table. The second phase will be concentrated on pumping mobilized free phase hydrocarbons from the subsurface. The third phase will be concentrated on removing volatile hydrocarbons through steam distillation. Each phase of the project is expected to require approximately 10 days. However, if additional time is required to achieve the goals of a phase, UCB will notify the U.S. Navy and a decision will be made regarding extending the length of the three-well treatability test.

7.7.1 Operational Monitoring

Operational monitoring will be conducted throughout the three-well treatability test to monitor the performance of the steam injection/extraction system and the effluent treatment system as well as to monitor for the outward migration of contaminants from the treatment zone. Table 7-2 summarizes the operational monitoring that will be conducted and the frequency of the monitoring.

7.7.1.1 System Monitoring

Temperatures, pressures, and/or total flows will be monitored at 28 points within the effluent treatment system; monitoring points are shown on Figure 7-12 and the measurements that will be obtained at each point are summarized in Table 7-3. Flow measurements are needed to determine the steam injection rates and the rate at which hydrocarbons are being removed from the subsurface. The measurement of the temperature and the total volume flow rate of both liquid and vapor phases is also required to determine the amount of energy removed from the system and to estimate the total volume of hydrocarbons removed. Accurate measurements of the amount of energy injected into the subsurface as steam will be needed to accurately estimate the energy that is used to heat up the subsurface. Pressures will be monitored to control the pressure of the compressed air injected to drive the pumps installed in the injection/extraction wells, control the steam injection pressure at the well head, and monitor the vapor pressure of the vapor mixture in the vapor extraction line, and monitor the pressure before and after the vacuum blower.

For the three-well treatability test, thermocouples will be installed to monitor temperatures, pressure gauges will be installed to monitor pressures, and flow totalizers will be installed to monitor total flow at the points indicated on Figure 7-12. These measurements will be obtained daily at a minimum. Temperature, pressure, and total flow measurements will be taken manually and recorded on a standardized form such as the one presented on Figure 7-14.

7.7.1.2 Temperature Observation Wells

Daily temperature measurements will also be obtained from each temperature observation well at a minimum. The measurements will be obtained manually to monitor propagation of the steam zone. If possible, an electronic data acquisition system will be used to continuously record temperatures at each temperature observation well. If an electronic data acquisition system is used, manual measurements will be obtained daily to provide backup. Plots of temperature versus depth will be generated every one to three days to monitor the location of the steam and heated zones around the injection/extraction wells. Manual measurements will be recorded on standardized form such as the one presented on Figure 7-15.

7.7.1.3 Resistivity Measurements

To evaluate changes in soil resistivity, weekly resistivity measurements will be made using the electrode wells and surface electrodes during operation of the SEE system to generate a two-dimensional, vertically oriented resistivity tomograph for mapping progress of the steam. These tomographs will also be generated at the completion of the three-well treatability test.

7.7.1.4 Groundwater Monitoring

Water levels and gas pressures will be monitored daily in the groundwater monitoring wells using pressure transducers and an electronic data logger. The measurements will be obtained to monitor the movement of groundwater outside the treatment zone. The wells will be sampled at day 15 and day 30 of the test to detect changes in the concentrations of contaminants. Monitoring, sampling, and analytical methods are identified in the Sampling and Analysis Plan for the Three-Well Treatability Test, Appendix F of the Work Plan. Water levels will also be monitored within the injection/extraction wells using pressure transducers and an electronic data logger.

7.7.1.5 Compliance Monitoring

During operation of the three-well treatability test, the liquid stream from the effluent treatment system will be treated with carbon adsorption canisters. Sampling of the effluent from the carbon adsorption canisters (Monitoring Point 31, Figure 7-12) will provide a demonstration that the EBMUD discharge requirements are being met. Discharge limitations will be established once the discharge permit is granted. For the first week of operation, effluent samples will be collected daily from this monitoring point. Analyses that will be performed on these samples are specified in the Sampling and Analysis Plan for Three-Well Treatability Test, Appendix F. Depending on the results of the sampling, the sampling frequency and number of analyses may be reduced after one week following consultation with the Resident Officer in Charge (ROICC) and EBMUD if sampling results indicate that discharge limitations are consistently met.

During operation of the three-well treatability test, the gaseous stream from the vapor effluent treatment system will be treated using a thermal oxidation unit and vapors from the oil/water separators and oil storage tank will be treated with carbon canisters. Sampling of the effluent from these units (Monitoring Points 33 and 35) will demonstrate compliance with Bay Area Air Quality management District (BAAQMD) limitations which are one pound per day of hydrocarbons and 0.05 pounds per day of benzene. The sampling frequencies are summarized in Table 7-2. Methods for collection and analysis of these samples are specified in the Sampling and Analysis Plan for the Three-Well Treatability Test, Appendix F. Depending on the results of the sampling, the sampling frequency may be reduced after one week after consultation with the ROICC and the BAAQMD.

7.7.1.6 Performance Monitoring

Performance monitoring will be conducted to measure the total mass of hydrocarbons removed during the three-well treatability test and to evaluate the relative hydrocarbon removal rates of the injection/extraction wells, passive surface containment system, and the actively cooled surface containment system. Samples for the measurement of the total mass of hydrocarbon removal will be laboratory analyzed to provide a high degree of accuracy. Vapor samples to assess the relative removal rates of each component will be field analyzed and liquid samples for this assessment will be laboratory analyzed.

Samples for the calculation of the total hydrocarbon mass removal through liquids and vapors will be collected from Monitoring Points 30 and 34. Samples for monitoring the relative performance

of the injection/extraction wells, passive containment system, and actively cooled containment system will be collected from Monitoring Points 7, 8, 9, 11, 12, 13, 14, 15a, and 15b. Monitoring points for the injection/extraction wells will only be sampled when the injection/extraction well is in operation. Analyses to be performed on these samples are specified in the Sampling and Analysis Plan for the Three-Well Treatability Test, Appendix F.

Hydrocarbon concentrations in the effluent streams are expected to be highest at the onset of the three-well treatability test and to decrease rapidly until they level off at a relatively constant recovery rate. To obtain data for an accurate calculation of the hydrocarbon mass removed, samples will be collected from all performance monitoring points at 4 hour intervals during the beginning of operation. For those samples that will be laboratory analyzed, samples collected at eight hour intervals will initially be analyzed on a rush turn around basis and the intermediate samples collected will be stored at the laboratory for potential analysis. The intermediate samples will only be analyzed if there is greater than a five fold difference in the hydrocarbon concentrations identified in the 8 hour samples. As the effluent concentrations level off, the sampling frequency will be adjusted to an interval sufficient to detect a five fold change in hydrocarbon concentrations. The volume of free phase hydrocarbons obtained will be measured in the oil storage tank weekly and the tank will be emptied when full. A sample of free phase hydrocarbons for chemical analyses described in Appendix F will be collected each time the tank is emptied or at the completion of the test if the tank is not filled during the three-well treatability test.

7.7.2 Overview of Operation

During Phase 1, steam will initially be injected through the lower screened interval of one injection/extraction well and groundwater displaced by the steam will be pumped from the other two wells. A mass balance will be performed and steam rates will be adjusted to ensure that they do not exceed the volume of groundwater removed by pumping. This is a precautionary measure to reduce the outward displacement of groundwater and dissolved contaminants during the injection of steam.

Propagation of the steam zone during this phase will be estimated using the Marx-Langenheim (1959) model and monitored in the field using the temperature monitoring wells and ERT. The results of the temperature readings and the ERT profiles will be used to calibrate the model so that it can be used to accurately predict the propagation of the steam zone. This model is easily run on a hand held calculator. Two and three dimensional numerical models (M2NOTS based) will also be used to predict the movement of steam and hydrocarbons in the subsurface. Excel spreadsheets linked to data files of extraction flow rates, steam injection rates, inlet and outlet pressures and temperatures, and surface covering temperatures, will be used to calculate energy balances and heat losses to the surface. Results of the modeling and field monitoring will be interactively used to determine the most effective steam injection and pumping scheme to bring the subsurface to steam temperatures quickly and to keep the steam zone within the surface containment systems. The injection and pumping scheme will be adjusted accordingly.

The second phase would start once the subsurface is brought up to steam temperatures within the treatment zone. During this phase, a cone of depression will be maintained in one injection/extraction well by pumping; separate phase hydrocarbons produced as a result of heating will be pumped from the well. The intake of the pump will be maintained near the top of the water surface to recover both groundwater and separate phase hydrocarbons. The pump will be maintained at the shallowest depth necessary to obtain optimal recovery of free phase hydrocarbons and minimize the volume of groundwater pumped to maintain the cone of depression. A vacuum will be applied the other injection/extraction wells during this phase to recover vapor phase hydrocarbons produced as a result of heating.

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The third phase will begin once visible free phase hydrocarbons are no longer recovered. During this phase, steam will be injected into both screened intervals of one injection/extraction well at a time. Injection of steam will be cycled by alternating the injection well daily. Effluent steam from the system will be monitored daily for compositional changes in the hydrocarbons contained in the effluent vapors. The three-well treatability test will be discontinued once the concentrations of C12 to C16 hydrocarbons and BTEX drop to one or two orders of magnitude lower than the concentrations identified in the initial vapor effluent.

7.8 Performance Objectives

The primary measure of the performance of the laboratory treatability tests was the removal of volatile hydrocarbons by the application of steam. Results of the first laboratory test indicate that the more volatile hydrocarbons are removed under laboratory conditions. The second laboratory treatability test confirmed these results.

The three-well treatability test will provide data regarding 1) the ability of the subsurface materials at Site 13 to transmit steam and allow a sufficient steam zone to develop for the recovery of hydrocarbons from the subsurface; 2) the ability of SEE to recover separate phase hydrocarbons; and 3) the ability of SEE to remove hydrocarbons through steam distillation under field conditions. These data are necessary to assess the total potential of SEE to remove hydrocarbons from the subsurface and cannot be obtained from laboratory treatability tests.

The primary measures of performance for the three-well treatability test will be the ability to maintain a sufficient steam zone and the mass of free phase and volatile hydrocarbons removed. The size and shape of the steam zone obtained during the three-well treatability test will be used to determine necessary spacing for injection/extraction wells installed for the pilot-scale test. The mass of free phase hydrocarbons will be measured using flow totalizers after oil/water separator #2. The mass of volatile hydrocarbons removed will be estimated directly from the mass extracted with either steam or groundwater. The results of effluent sampling and flow measurements will be used in this estimate.

During early operations of the three-well treatability test, recovery of free phase hydrocarbons may be responsible for the largest mass of hydrocarbons removed from the subsurface. Recovery of the free phase hydrocarbons will continue until visible free phase hydrocarbons are no longer recovered.

The three-well treatability test will be stopped when removal rates for C12 to C16 range hydrocarbons and BTEX compounds identified in the liquid effluent samples drop to one to two orders of magnitude lower than the initial concentrations identified in the effluent; these hydrocarbons are considered the more volatile fraction of the total hydrocarbon range. C12 to C16 hydrocarbons are representative of the lighter diesel fraction of the total hydrocarbons.

Upon completing the three-well treatability test, post-demonstration sampling will be conducted to evaluate the concentrations of hydrocarbons left in place and the removal of the volatile components of the hydrocarbon mass. This sampling will be conducted if: 1) the three-well treatability test is successful at removing a significant mass of hydrocarbons either through removal of separate phase hydrocarbons or steam distillation; and 2) at least a two order of magnitude difference is observed in the total hydrocarbon or BTEX concentrations of the system effluent streams from the beginning to the end of the three-well treatability test. Soil samples from borings will be analyzed as specified in Appendix F to demonstrate whether there has been a reduction in the level of total petroleum hydrocarbons in the soil. Leachability tests will also be conducted to evaluate the leachability of the hydrocarbons left in place. Performance monitoring performed for the effluent treatment system will provide a measure of the total and volatile hydrocarbon mass

removed during the three-well treatability test, and analysis of the recovered product will provide an evaluation of the mass of total and volatile hydrocarbon mass removed with the product.

The decision to proceed with the 15-well pilot-scale test will be based on the results of the three-well treatability test. The 15-well pilot-scale test would be justified if:

- the three-well treatability test is successful at reducing hydrocarbon concentrations in the effluent to one or two orders of magnitude lower than the initial concentrations identified in the effluent.
- the three-well treatability test is successful at reducing the volatile components and leachability of the hydrocarbons in the subsurface at Site 13.

8. REPORTING

Reporting that is required for this three-well treatability test includes preparation of this Work Plan and a letter report documenting the operation of the three-well treatability test. These documents will be submitted to the Navy for review. Design documents for the system will be prepared as part of the bid documents for potential subcontractors; the design documents will be available to the U.S. Navy for inspection, but the documents will not be submitted to the U.S. Navy for review.

9. IMPLEMENTATION PLAN

The implementation plan consists of a list of tasks to be completed for the three-well treatability test and an implementation schedule. The following sections provide an overview of the work to be performed. Bid documents for potential subcontractors who will install the system will be based on a detailed, or 100%, design. The Sampling and Analysis Plan for the Laboratory Treatability Tests is included in Appendix E. Sampling and analyses that will be conducted in support of the three-well treatability test is described in Appendix F. All work will be performed in accordance with the CQCP (Appendix D), Site Health and Safety Plan (Appendix H), and the Environmental Protection Plan (Appendix I).

9.1 TASKS

9.1.1 Laboratory Treatability Tests

This section identifies the tasks performed for the laboratory treatability tests in support of the three-well treatability test. The tasks are as follows:

- collection and compositing of soil samples for treatability testing;
- analysis of pre-steaming soil sample for characterization of initial hydrocarbon concentrations;
- preparation of laboratory column;
- performance of the steam injection experiment, including laboratory analysis of effluent liquid samples; and

• analysis of post steaming soil samples for characterization of post steaming hydrocarbon concentrations.

The soil and effluent and soil samples are analyzed at an outside commercial laboratory. The remainder of the tasks are performed by UCB. The tasks are described in more detail in the Sampling and Analysis Plan for Laboratory Treatability Tests in Appendix E of this Work Plan.

9.1.2 Three-Well Treatability Test

This section provides general descriptions of the tasks to be performed for the three-well treatability test. All tasks will be conducted by UCB and their contractor except as noted below. Field activities can be grouped into the following types of tasks:

- design and subcontractor procurement,
- site preparation and characterization,
- injection/extraction well installation and testing,
- treatment equipment procurement and installation,
- observation and monitoring well installation,
- surface containment installation,
- system operation, and
- post demonstration sampling.

9.1.2.1 Preparation of Design and Bid Documents

Design and bid documents are prepared as part of this task. The documents will be prepared by UCB with the assistance of a subcontractor. The design will be of sufficient detail to obtain reliable bids from potential subcontractors. The bid documents for standard services and equipment will then be sent out to a minimum of three subcontractors for each subcontracted activity.

9.1.2.2 Procurement and Subcontracting

The bids received for each activity will be reviewed by UCB and the lowest technically acceptable bidder will be selected. Upon selection of a subcontractor, a subcontract will be issued as part of the subcontractor procurement process. Contracts for cone penetrometer testing (CPT), surface grading, mobilization the field-office trailer, injection/extraction well installation, and well development and sampling will be awarded first.

9.1.2.3 Utility Clearance

Prior to conducting any ground invasive activities, including CPT and well installation, the U.S. Navy will locate all underground utilities within the treatment zone and provide clearance for all planned sampling locations.

9.1.2.4 Cone Penetrometer Testing

CPT with laser-induced fluorescence will be used to delineate the vertical extent of the hydrocarbons within the treatment area. The information will be used to adjust locations and appropriate screened intervals for the injection/extraction wells. The planned locations of the 20 cone penetrometry soundings are shown on Figure 9-1. CPT will be performed by a subcontractor to UCB and supervised by UCB personnel and a registered geologist.

9.1.2.5 Mobilization of Field-Office Trailer and Establishment of Staging Areas

The field-office trailer will be brought to the site and placed at the location shown on Figure 7-2 by subcontractors to UCB. Utilities, including telephones, electricity, and water will be connected by the U.S. Navy, UCB subcontractors, or representatives from the utility industry, depending on cost and compliance with standard procedures. Staging areas will also be established for the storage of field equipment/supplies and field derived wastes awaiting disposal.

9.1.2.6 Injection/Extraction Well and Temperature Monitoring Well Fabrication

Once information regarding the vertical distribution of hydrocarbons in the soil is obtained from CPT, the locations and design of the injection/extraction wells will be finalized by UCB. These wells and the temperature observation wells will be fabricated by an off-site vendor. Fabrication will require approximately two weeks.

9.1.2.7 Surveying of Ground Elevations and Grading

Ground elevations and locations of existing monitoring wells have already been surveyed by a subcontractor to UCB. Once the CPT is completed and the locations of the extraction and injection wells are finalized, the surface will be graded by a subcontractor to UCB. The grading will facilitate installation of surface covers and drainage from the system. For the three-well treatability test, the grading will be performed only for the area indicated on Figure 7-9. Specifications for the grading will be provided in the bid documents.

9.1.2.8 Installation and Development of Injection/Extraction Wells

Once surface grading is complete, the injection/extraction wells will be installed by a subcontractor to UCB. Sampling and analysis that will be conducted during installation of the injection/extraction wells and well development methods are described in Appendix F. The wells will be developed by a subcontractor to UCB under the supervision of UCB personnel.

9.1.2.9 Aquifer Testing

Upon installation and development of the injection/extraction wells, pumping tests will be performed by UCB under the supervision of a certified hydrogeologist to identify the transmissivity and storativity of the water bearing materials at Site 13. The aquifer testing plan is

included in Appendix F. The information obtained will be used to review the design specifications for the treatment system and modify equipment and piping sizes as necessary.

9.1.2.10 Treatment Equipment Procurement

Upon finalization of the design specifications for the treatment system equipment, the treatment equipment identified in Section 7.6 and specified on the process and instrumentation diagram (Figure 7-13) will be rented. Subcontractors will be procured to install the equipment. The schedule for delivery and installation of the rental equipment will be designed to minimize overall rental fees.

9.1.2.11 Installation of Temperature Observation, Electrode, and Groundwater Monitoring Wells

Upon installation of the injection/extraction wells, the temperature observation, electrode, and groundwater monitoring wells will be installed as described in Appendix F. These wells will be monitored during the three-well treatability test to monitor the performance of the treatment system in the subsurface. The wells will be installed by subcontractors to UCB under the supervision of UCB and LLNL personnel and a registered geologist.

9.1.2.12 Development of Groundwater Monitoring Wells and Sampling of all Wells

Upon installation of the groundwater monitoring wells, they will be developed by a subcontractor to UCB under the supervision of UCB personnel. Following development, groundwater samples from these wells and the injection/extraction wells will be obtained and analyzed as described in the Sampling and Analysis Plan for the Three-Well Treatability Study, Appendix F. Groundwater samples will be obtained and laboratory analyses will be performed by subcontractors to UCB.

9.1.2.13 Survey of Surface Elevations and All Well Locations

Once all wells have been installed and the site has been graded, surface elevations will be surveyed again along with the locations and elevations of all newly installed wells. The newly installed wells include the injection/extraction wells, groundwater monitoring wells, temperature observation wells, and electrode wells. Surveying will be conducted by a subcontractor to UCB.

9.1.2.14 Surface Containment System Installation

After the treatment area has been graded and the surface elevations have been resurveyed, the passive and actively cooled surface containment systems will be installed. Specifications for these systems will be included in the bid documents and the systems will be installed by a subcontractor to UCB.

9.1.2.15 Installation of Treatment System and Above-Ground Piping Networks

After the surface containment systems have been installed, the above-ground piping networks and treatment system will be installed. The treatment system is described in Section 7.7 and specifications for the treatment equipment and the above ground piping will be included in the bid documents. The system and piping networks will be installed by a subcontractor to UCB under the supervision of UCB personnel.

9.1.2.16 System Operation

Once the treatment systems and above-ground piping networks have been installed, the system will be operated by UCB for approximately 30 days. Operational monitoring that will be conducted is described in Section 7.7, and sampling and analysis that will be conducted as part of the operational sampling is further described in the Sampling and Analysis Plan for the Three-Well Treatability Study, Appendix F of this Work Plan. One week will be required for system mobilization prior to startup of the system.

9.1.2.17 Post Demonstration Sampling

Post-demonstration sampling, including the installation of soil borings and collection and laboratory analyses of subsurface soil samples, will be conducted at the completion of the three-well treatability test. The sampling will be conducted to demonstrate whether SEE was successful in removing the more volatile hydrocarbon components from the subsurface oily materials. Sampling and analysis activities that will be conducted as part of this test are described in the Sampling and Analysis Plan for the Three-Well Treatability Test, Appendix F of this Work Plan. Installation of soil borings and soil sampling will be performed by a subcontractor to UCB under the supervision of UCB personnel and a registered geologist.

9.1.2.18 System Decommissioning

System decommissioning will be either complete or partial. Decommissioning will be complete if the planned 15-well field treatability test is canceled and partial if the 15-well test is conducted. Complete decommissioning would involve removal of all above-ground piping at the site, removal of the surface covers, removal of vapor and liquid treatment systems, decommissioning of all wells installed solely for the treatability test, and removal of the office-trailer. Partial decommissioning would involve removal of all piping and systems not required for the 15-well pilot test. System decommissioning would be performed by a subcontractor to UCB.

A decision regarding the degree of and schedule for system decommissioning will be made on the basis of the decision of whether to proceed with the 15-well pilot-scale test. This decision will be made after the letter report for the three-well treatability test has been submitted and reviewed. This task is not included on the schedule discussed in Section 9.2 because the schedule for decommissioning is uncertain.

9.2 IMPLEMENTATION SCHEDULE

Figure 9-2 presents an implementation schedule for the three-well treatability test. The schedule includes all of the tasks identified above. As indicated on the schedule, it is expected that the three-well treatability test will require approximately 28 weeks to complete after notice to proceed.

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TABLES

Table 6-1

Summary of

Pilot-Scale Treatability Study Data Needs

Steam Enhanced Extraction

Site 13

Data Need	Activity			
Assessment of Steam Distillation	Laboratory treatability test for removal of total hydrocarbons			
	Three-well treatability test			
Leachability of Hydrocarbons Remaining in place	Three-well treatability test			
Suitability of Site 13 Soils	Three-well treatability test			
Mobilization of Free Phase Hydrocarbons	Three-well treatability test			

Table 7-1 Effluent Treatment Equipment Specifications

Designation	Equipment Type	Capacity	Other Requirements
LT-01	Liquid Trap	Vapor flow rate: 280 scf/min Liquid flow rate: 1 gpm	
HX-01	Air-Cooled Heat Exchanger	Capacity: 450,000 Btu/hr Flow rate: 280 scf/min	Inlet temp: 100 °C Outlet temp: <40 °C
LVS-01	Liquid/Vapor Separator	Vapor flow rate: 280 scf/min Liquid flow rate: 1 gpm	
VB-01	Vacuum Blower	Vapor flow rate: 280 scf/min	Vacuum Pressure: -8 psig Inlet temp: <40 °C
OWS-01	Oil/Water Separator	Water flow rate: 1 gpm Oil flow rate: 1 gpm	
OWS-02	Oil/Water Separator	Water flow rate: 50 gpm Oil flow rate: 5 gpm	
CC-01	Vapor Phase Carbon Canister	Vapor flow rate: 1 scf/min Max. TPH Conc: 5,000 ppm	Min change-out time: 1 wk
CC-02	Vapor Phase Carbon Canister	Vapor flow rate: 1 scf/min Max. TPH Conc: 5,000 ppm	Min change-out time: 1 wk
CC-03	Liquid Phase Carbon Canister	Liquid flow rate: 50 gpm Max. TPH Conc: 3,000 ppm	Min change-out time: 1 wk
CC-04	Liquid Phase Carbon Canister	Liquid flow rate: 50 gpm Max. TPH Conc: 3,000 ppm	Min change-out time: 1 wk
OT-01	Oil Tank	Volume: 560 gallons Oil flow rate: 2 gpm	
TH-01	Thermal Oxidizer	Vapor flow rate: 280 scf/min Max. TPH Conc: 12,000 ppm	
PH-01	pH Treatment Unit	Liquid flow rate: 50 gpm	

Table 7-2
Operational Monitoring Frequencies

Sample Type	Minimum Frequency	Number of Sampling Locations
Temperature	daily	23
Total flows	daily	26
Pressure	daily	12
Temperature from temperature observation	daily	16
wells Electrical resistivity	weekly	7
Groundwater levels and vadose zone air pressures		
in groundwater monitoring wells	daily	4
Groundwater sampling from groundwater		
monitoring wells	every 15 days	4
Vapor and Liquid Compliance Monitoring	daily¹	4
Points Vapor and Liquid Performance Monitoring	every 4 hours ²	12
Points Free Phase Hydrocarbons	when tank is full	1

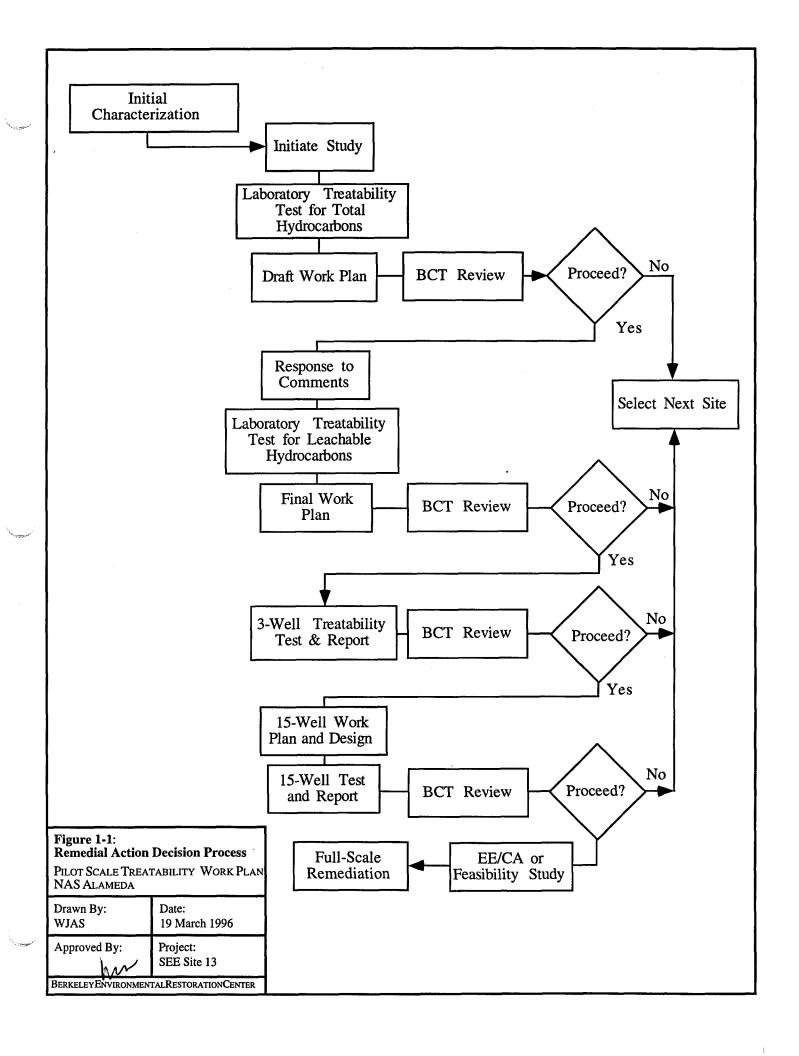
¹ Frequency to be revised after one week of sampling; analyses are specified in Appendix F.

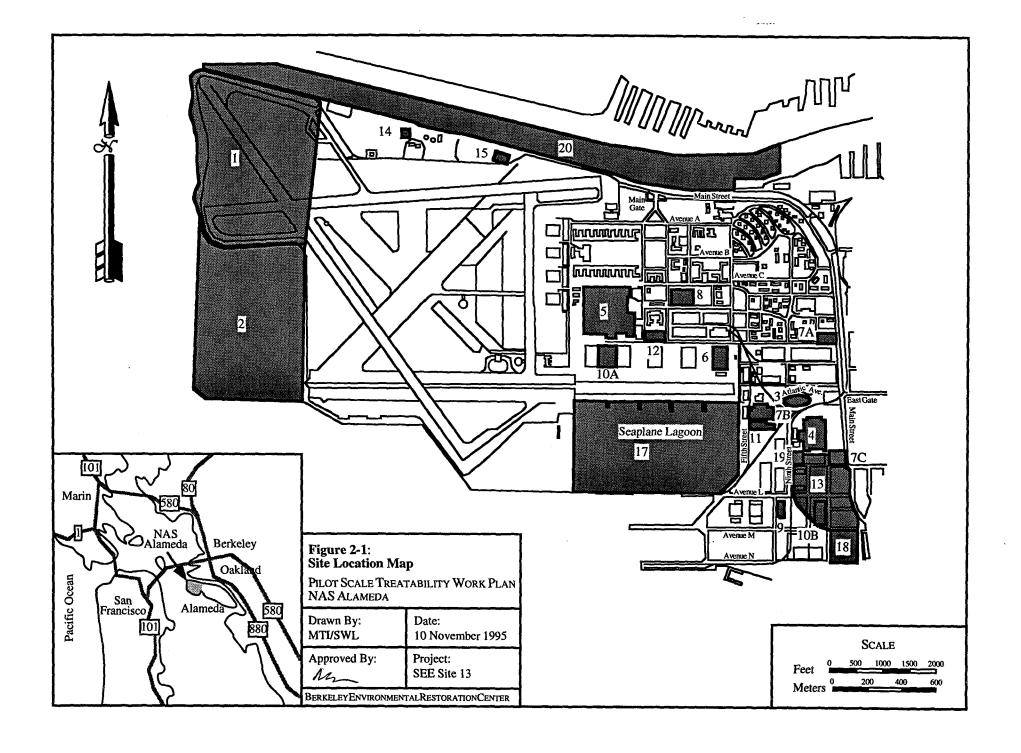
² Samples to be collected every 4 hours for the first 3 days of operation, sampling frequency to be adjusted to maintain less than a five fold difference in concentration between samples.

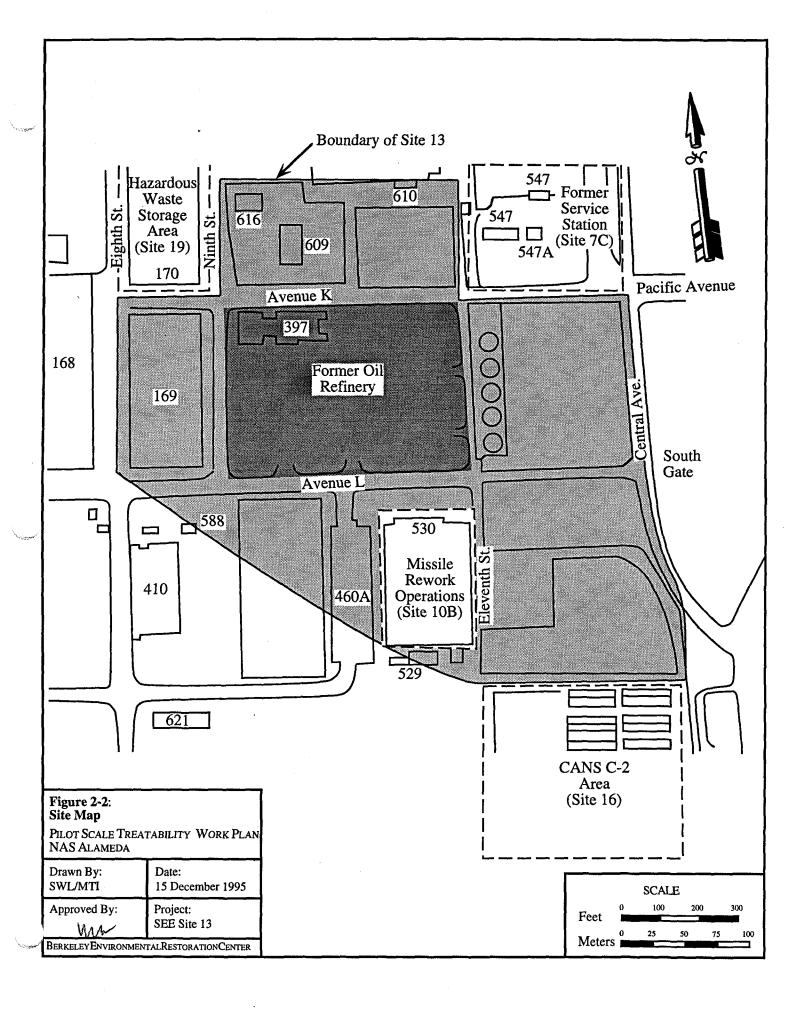
Table 7-3
Operational Monitoring Points for Effluent Treatment System Site 13, NAS Alameda

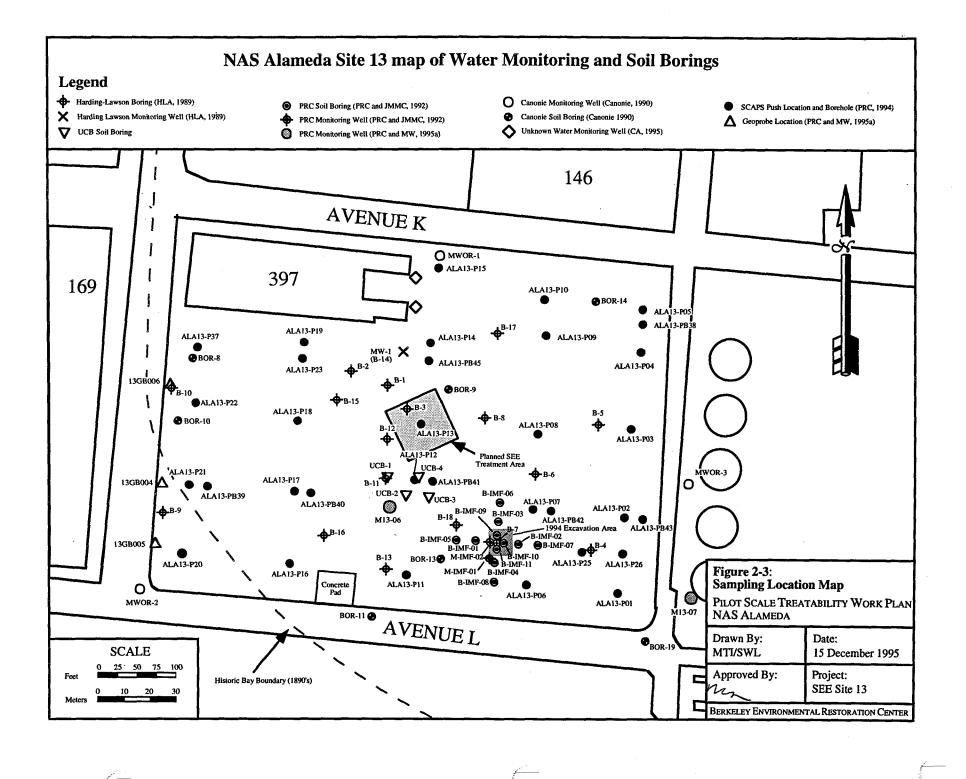
olo 15,1475 Alahou				Parame	eter	, , , , , , , , , , , , , , , , , , ,	પ
Monito Point	ring # Monitoring Point Description	Total Flow	Temperature	Pressure	Field Chemical	I ah Chemical	
	Injection Lines	104111011	Tomporataro	11055410	Tiola Chomical	zao Chemicui	
1	IEW-1	X	X	x			
2	IEW-2	X	X	X			
3	IEW-3	X	X	X			
Compre	essed Air (Pneumatic Pumps)						
4	IEW-1	X	X	X			
5	IEW-2	X	X	X			
6	IEW-3	X	X	X			
Effluen							
7	IEW-1 (liquid)	X	X			X	
8	IEW-2 (liquid)	X	X			X	
9	IEW-3 (liquid)	X	X			X	
10	Sum Liquid Effluent (Includes Surface Covers)	X	X				
11	IEW-1 (vapor)	X	X	X	X		
12	IEW-2 (vapor)	X	X	X	X		
13	IEW-3 (vapor)	X	X	X	X		
14	Liquid Effluent - Actively Cooled Surface Cover	X	X			X	4
15 a,b	Vapor Effluent - Surface Covers	X	X	X	X		
16	Effluent - Air cooled Heat Exchanger		X				
17	Vacuum Blower Inlet		X	X			
18	Condensate-Liquid Trap and liquid/Vapor Separator	X	X				
19	Hydrocarbon - Oil/Water Separator #1	X	X				
20	Hydrocarbon - Oil/Water Separator #2	X	X				
21	Water - Oil/Water Separator #1	X	X				
22	Water - Oil/Water Separator #2	X	X				
23	Condensate - Liquid Trap	X					
24	Condensate - Liquid/Vapor Separator	X					
25	Gas Inlet - Carbon Canisters 1 & 2	X					
26	Water Effluent - Carbon Canisters 3 & 4	X					
27	Water Inlet - Carbon Canisters 3 & 4	X		_			
28	Inlet - Thermal Oxidation Unit	X	X	X			
29	Oily Effluent from Oil/Water Separators					X	
30	Water Influent to Liquid Phase Carbon Canisters					X	
31	Water Effluent from Liquid Phase Carbon Canisters					X	
32	Vapor Influent to Vapor Phase Carbon Canisters					X	
33	Vapor Effluent from Vapor Phase Carbon Canisters				X		
34	Vapor Influent to Thermal Oxidizer					X	1
35	Vapor Effluent from Thermal Oxidizer				X		

FIGURES

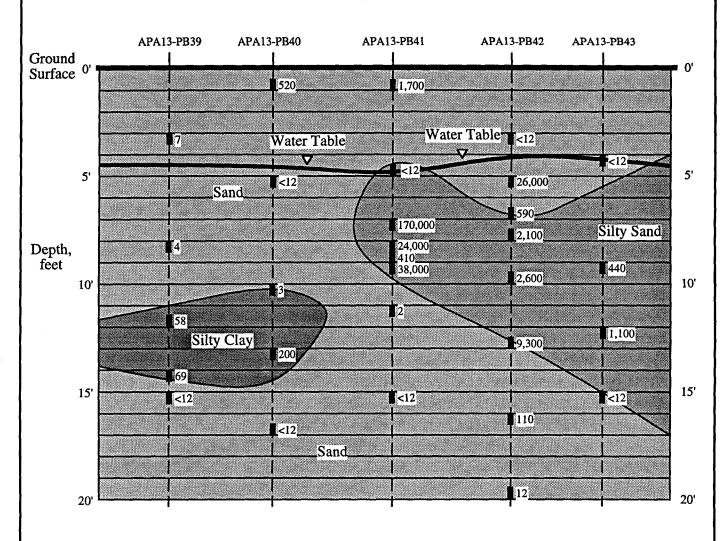


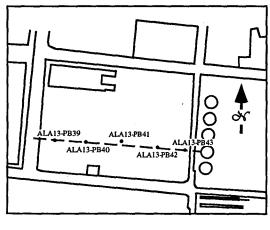






Simplified Geologic Cross-Section of Site 13



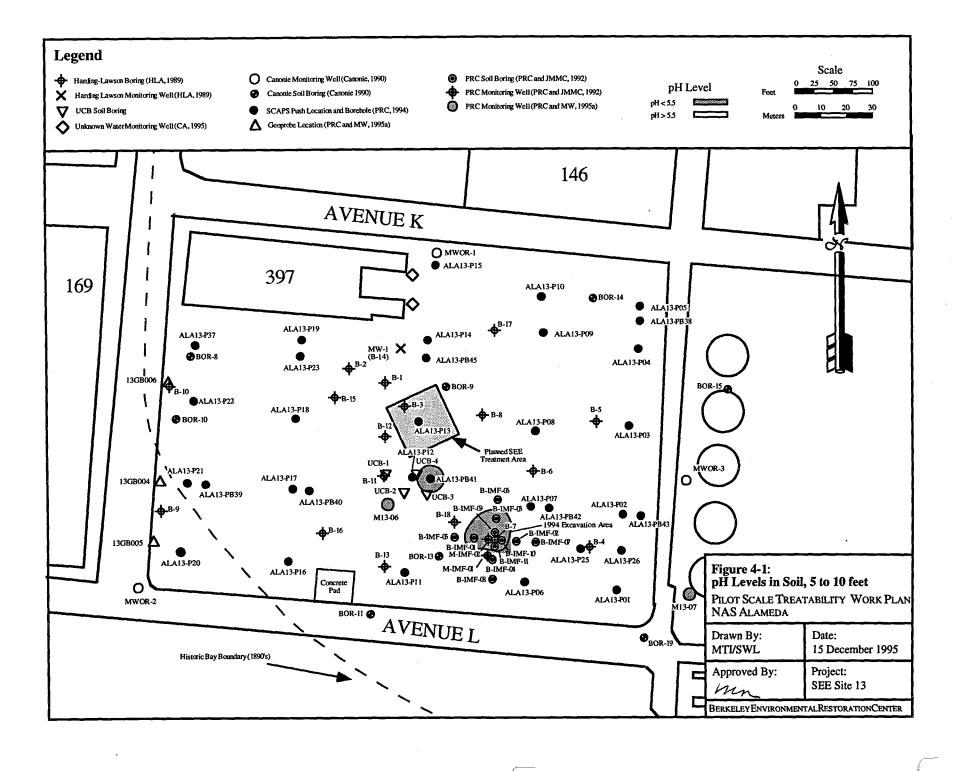


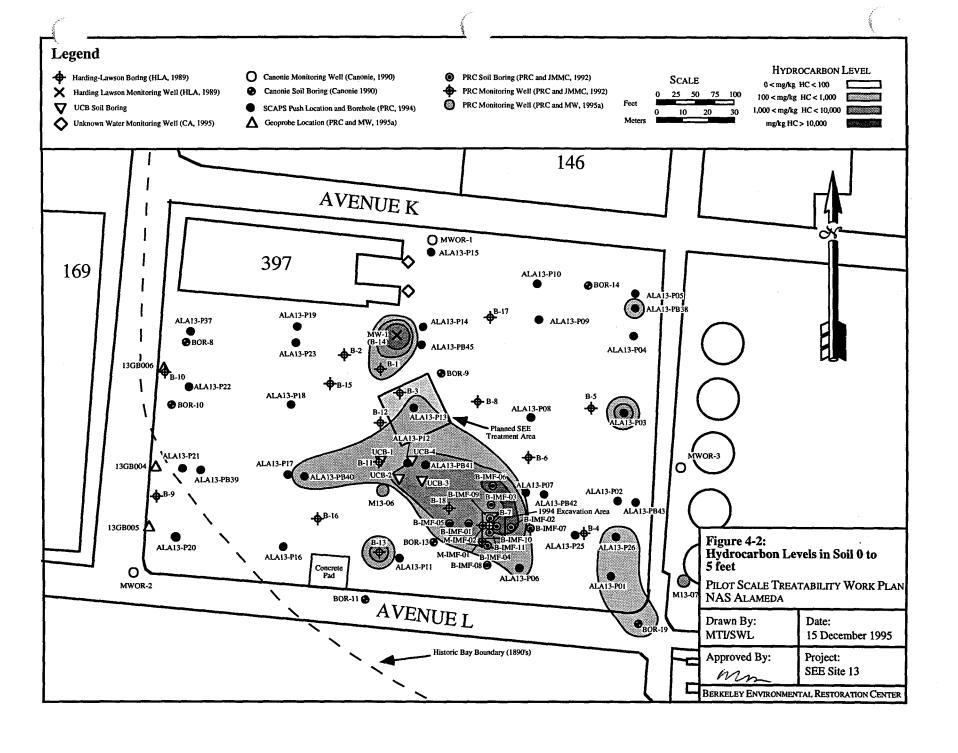
LEGEND Soil Sample Interval and the highest TPH concentration identified in the soil sample, mg/kg HORIZONTAL SCALE

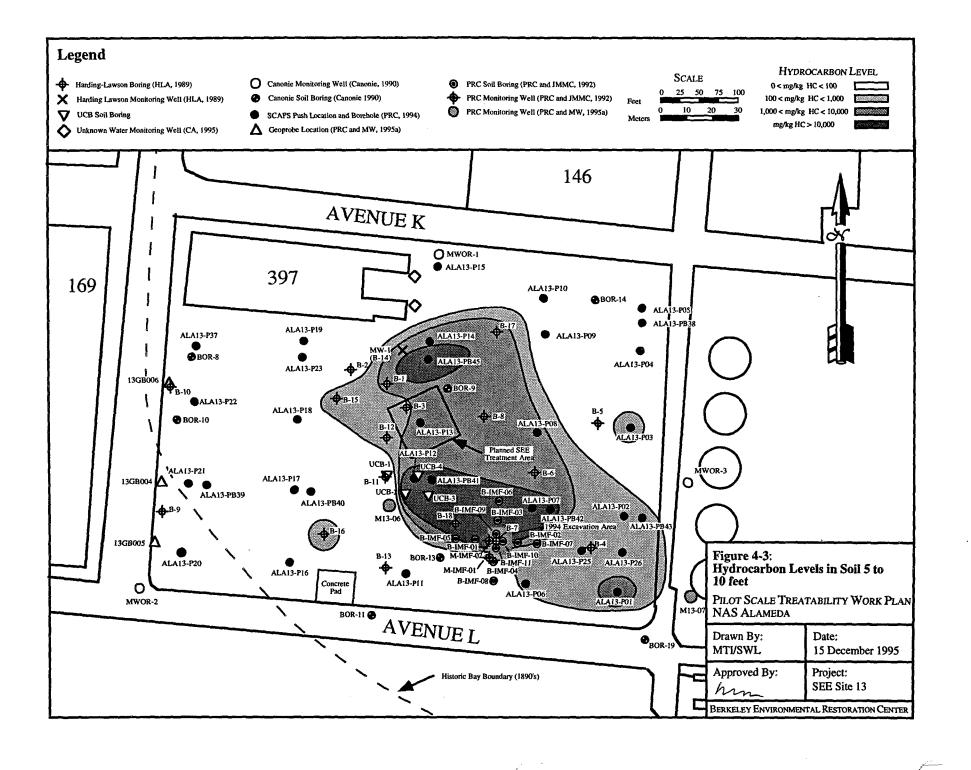
Figure 3-1: Geologic Cross Section, Site 13					
PILOT SCALE TREATABILITY WORK PLAN NAS ALAMEDA					
Drawn By: SWL/MTI	Date: 15 December 1995				
Approved By:	Project: SEE Site 13				

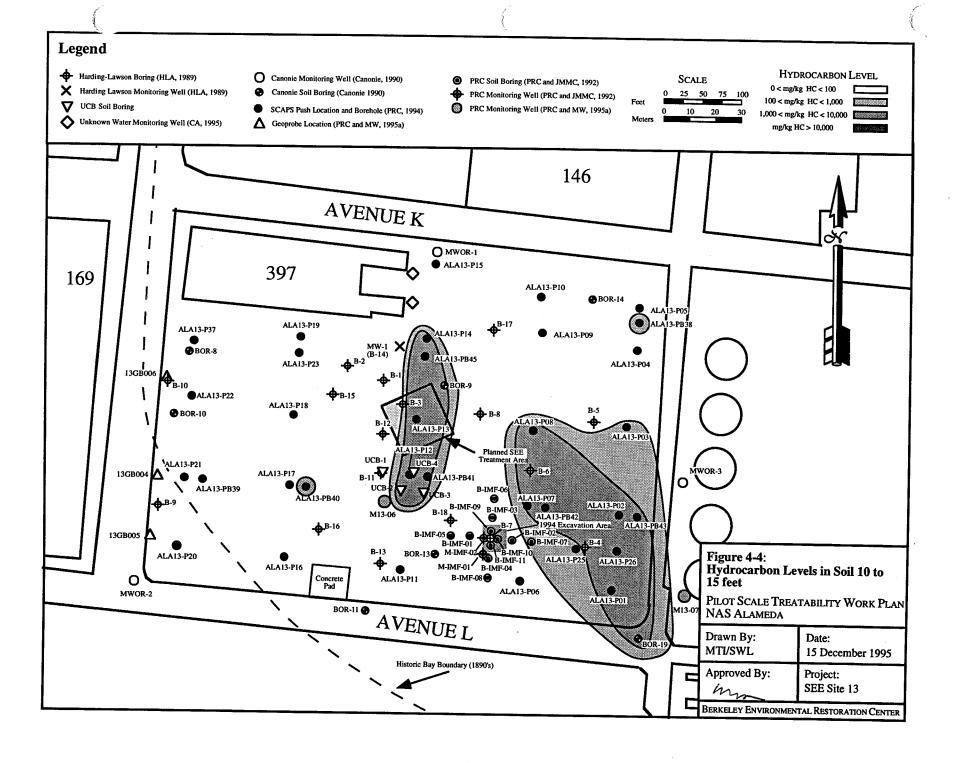
BERKELEY ENVIRONMENTAL RESTORATION CENTER

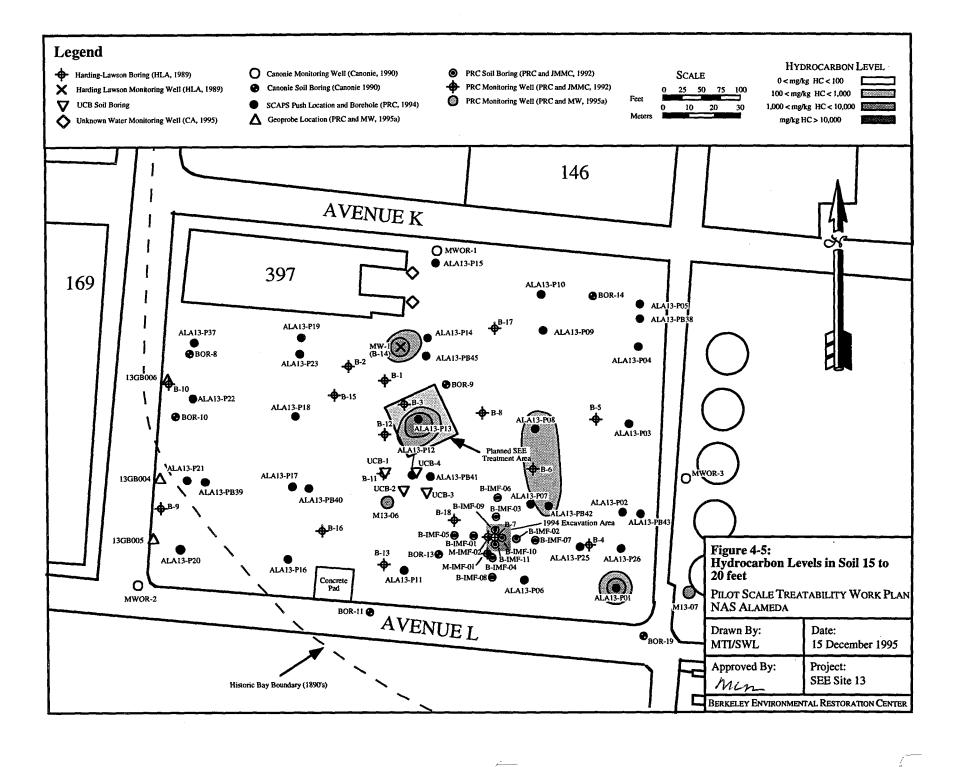
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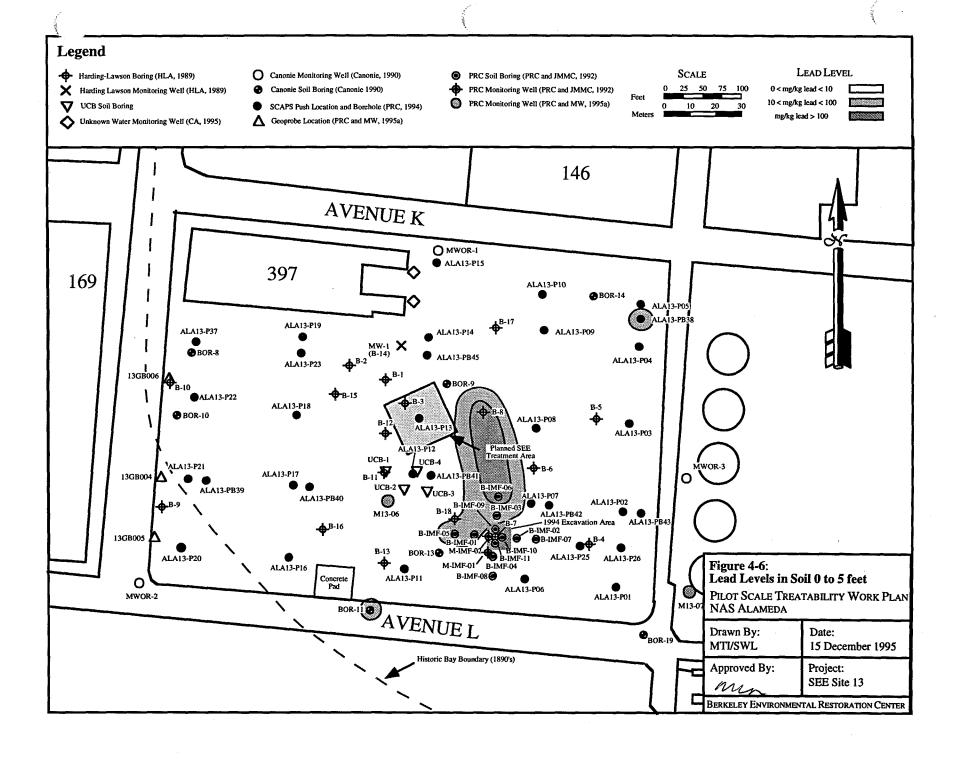


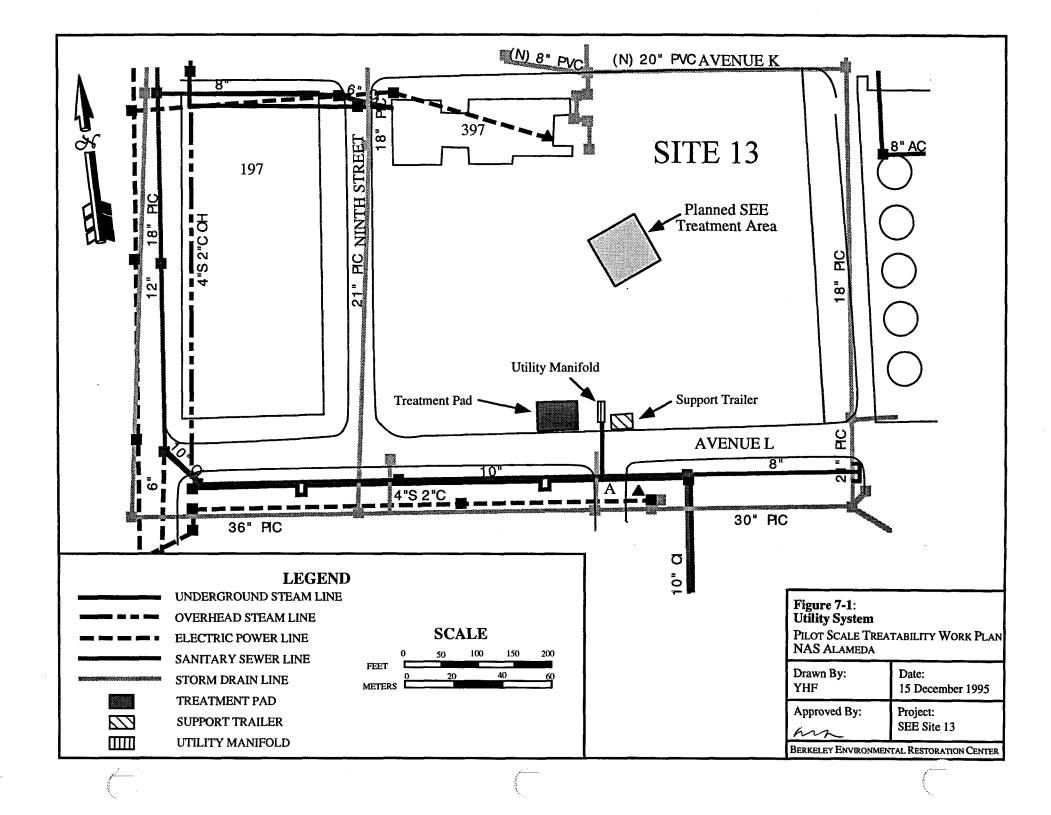


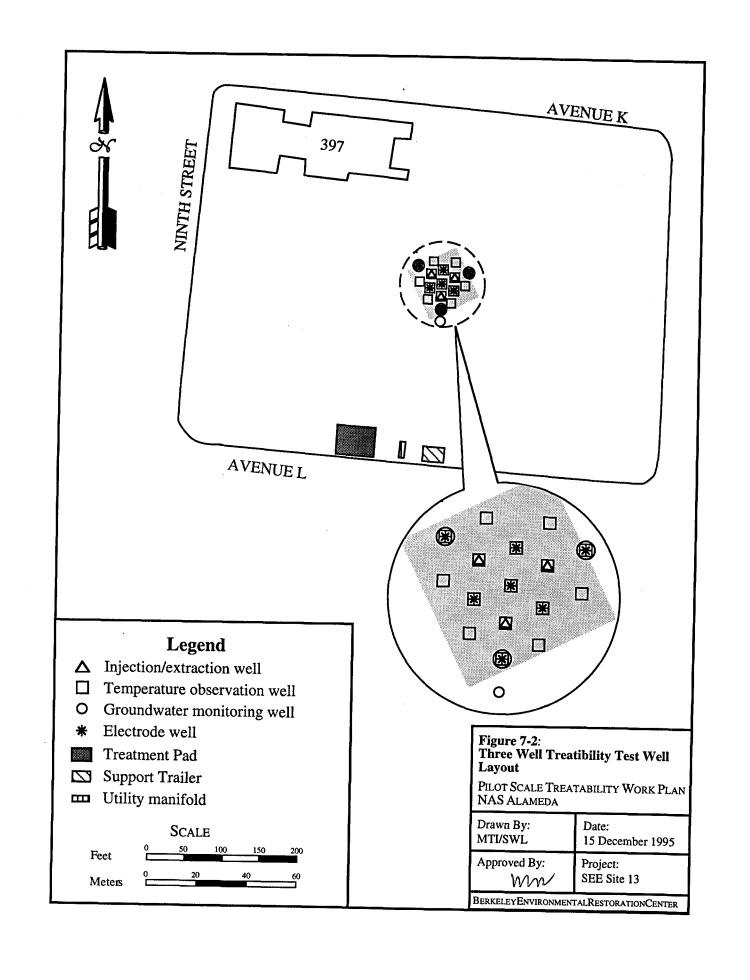


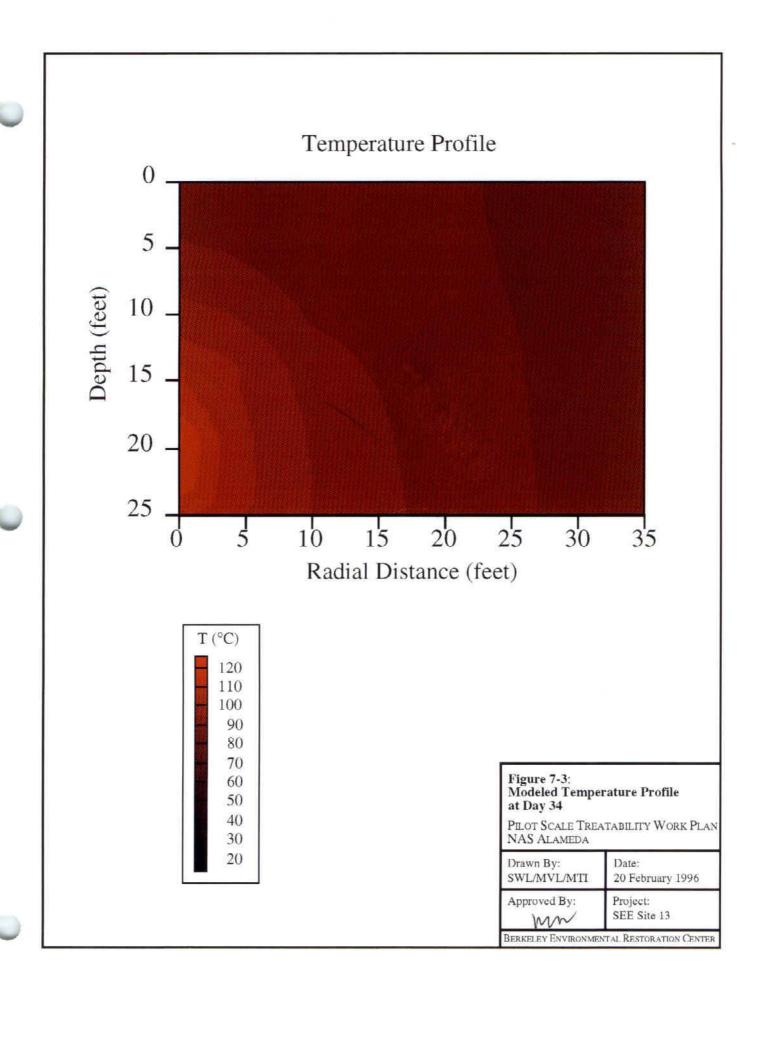




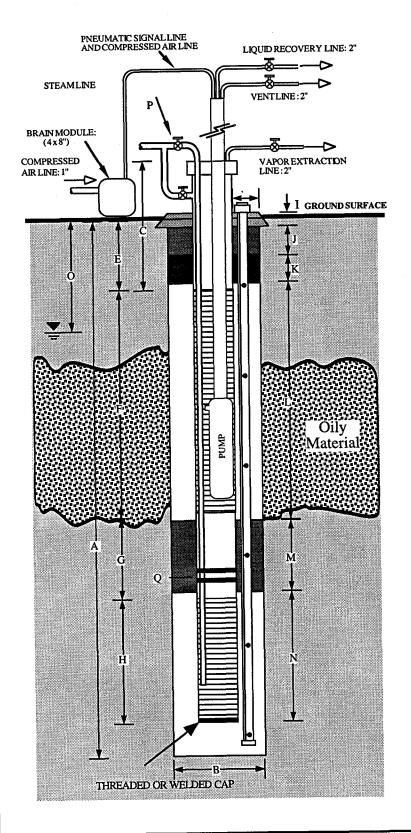








INJECTION/EXTRACTION WELL



EXPLORATORY BORING

- A. Total depth --- 30 ft
- B. Diameter ---12 in Drilling method --- Reverse Circulation

WELL CONSTRUCTION

- C. Casing length --- 8 ft
- D. Diameter --- 8 in
- E. Depth to top of screen --- 5 ft
- F. Screen length --- 15 ft
 Screen type --- continuous-slot screen
 V-type slot opening
 Slot size --- 0.02 in
 Screen material -- 304 Stainless Steel
- G. Casing length -- 5 ft Material --- 304 Stainless Steel
- H. Screen Length --- 5 ft
 Screen type --- continuous-slot screen
 V-type slot opening
 Screen size -- 0.02 in
 Screen material -- 304 Stainless Steel
- I. Surface seal --- 0.5 ft Material --- Concrete
- J. Backfill --- 2 ft Material --- Cement slurry with 5% Bentonite
- K. Seal --- 2 ft Material --- 3/8" Bentonite pellets (hydrated) 0.5 ft above top of screen
- L. Gravel pack --- 16 ft
 Material --- Silica Sand, RMC Lonestar
- M. Second Seal ---4 ft
 Material --- 3/8" Bentonite pellets (hydrated)
 0.5 ft above of top screen and
 0.5 ft below of bottom screen
- N. Gravel Pack --- 5.5 ft
 Material --- Silica Sand, RMC Lonestar
- O. Depth to Groundwater --- 4 ft
- P. Steam Line --- 1-1/4" DIA, Carbon Steel material 24 ft from ground level
- Q. Steel Plate thickness --- 1/4 in depth from ground surface --- 24 ft Steel Plate is 4 inches apart
- R. Metal Flange --- 4 in

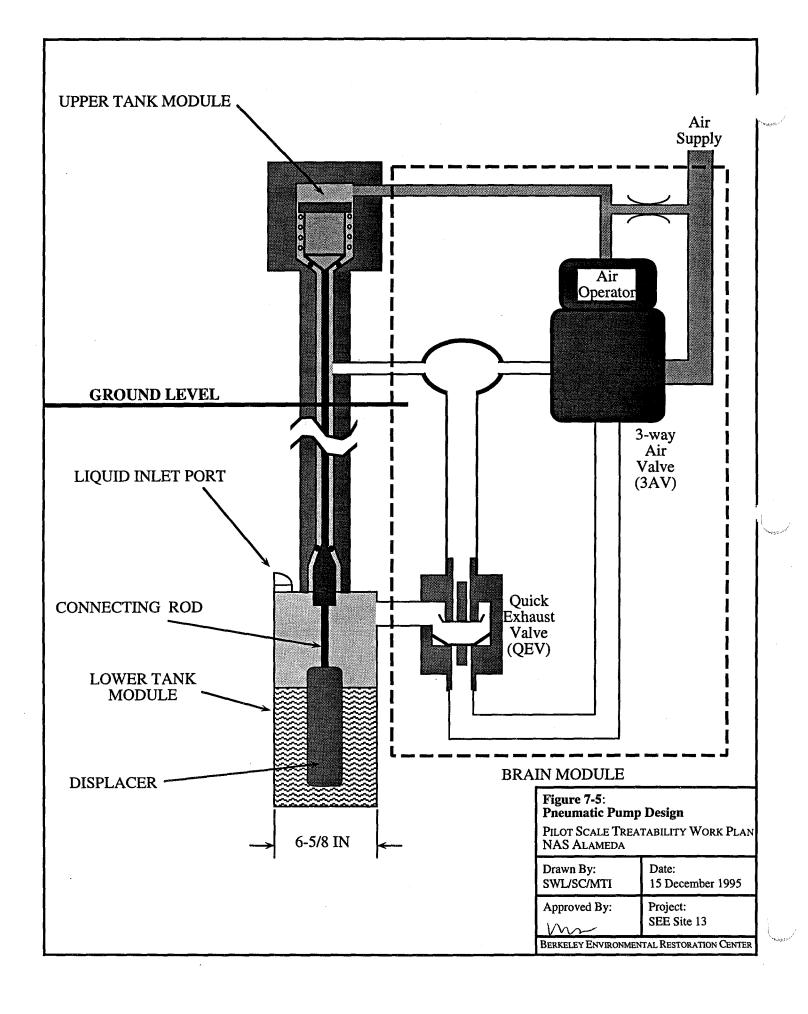
Figure 7-4: Injection/Extraction Well Design

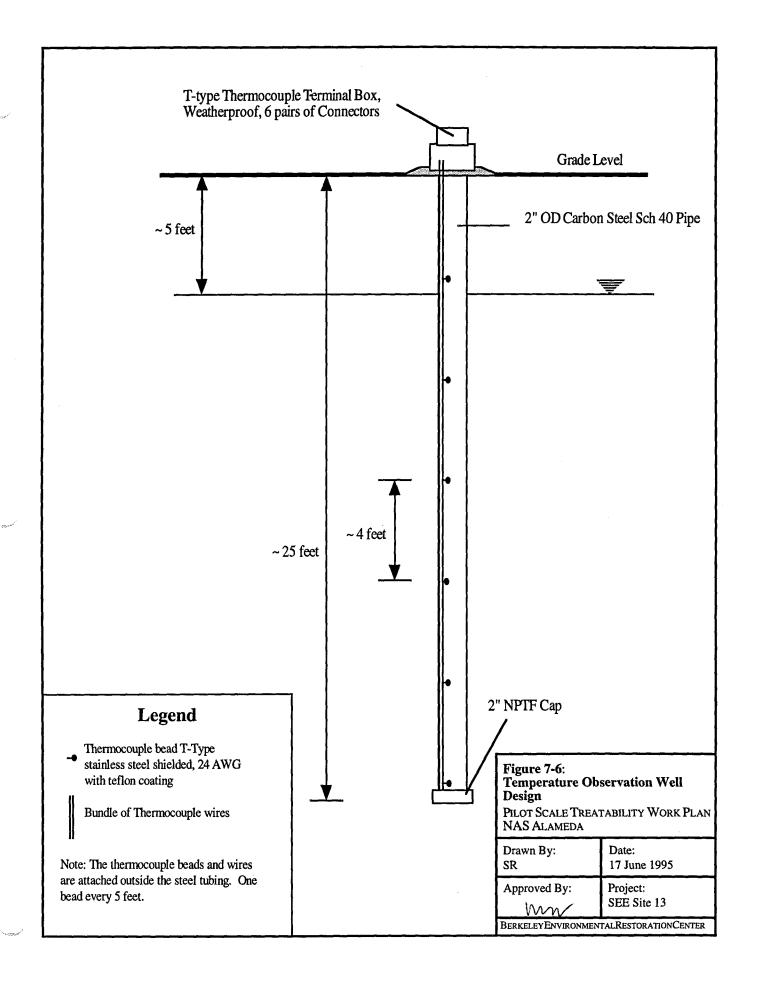
PILOT SCALE TREATABILITY WORK PLAN NAS ALAMEDA

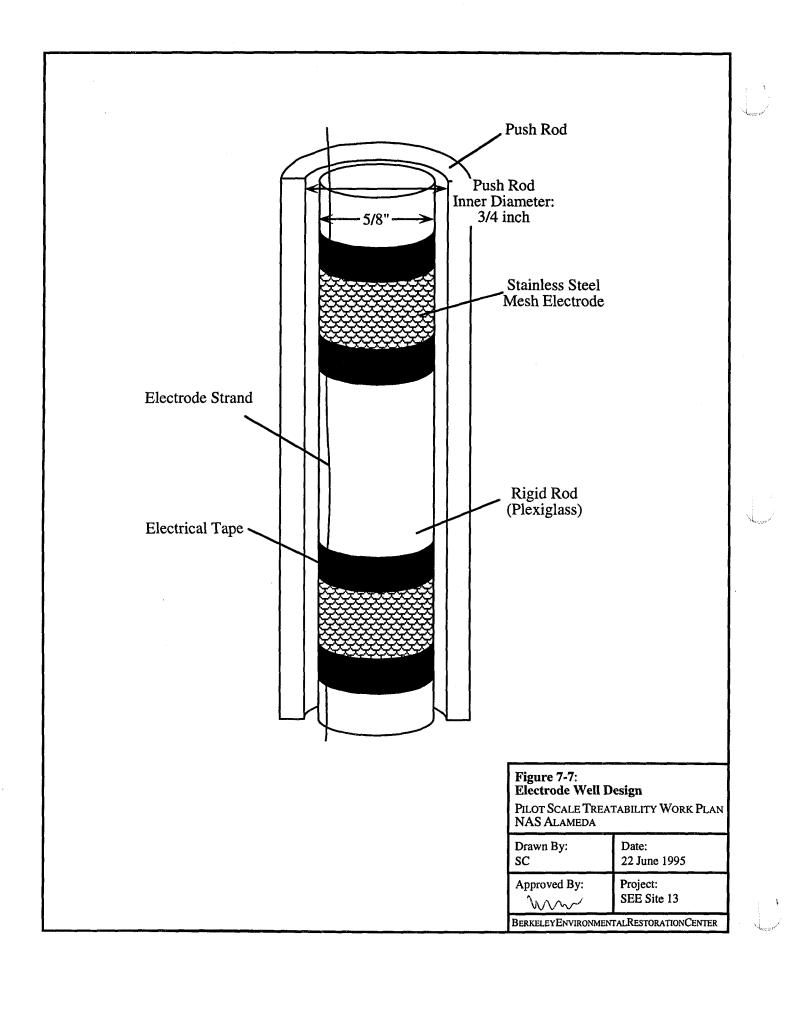
Drawn By: Date: 21 February 1996

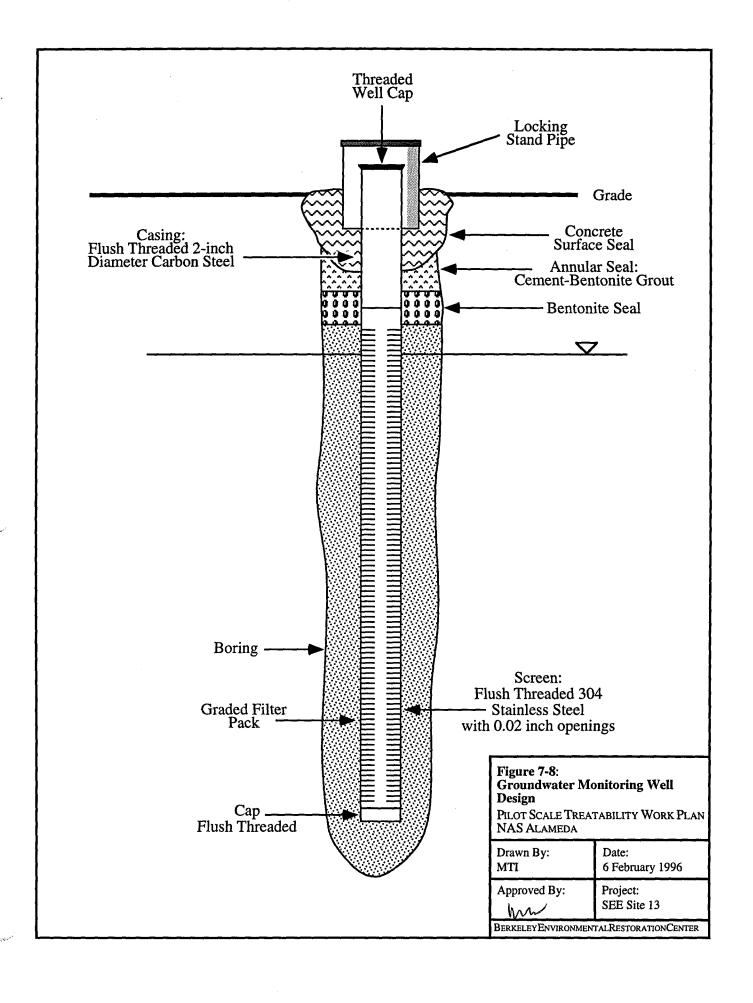
Approved By: Project: SEE Site 13

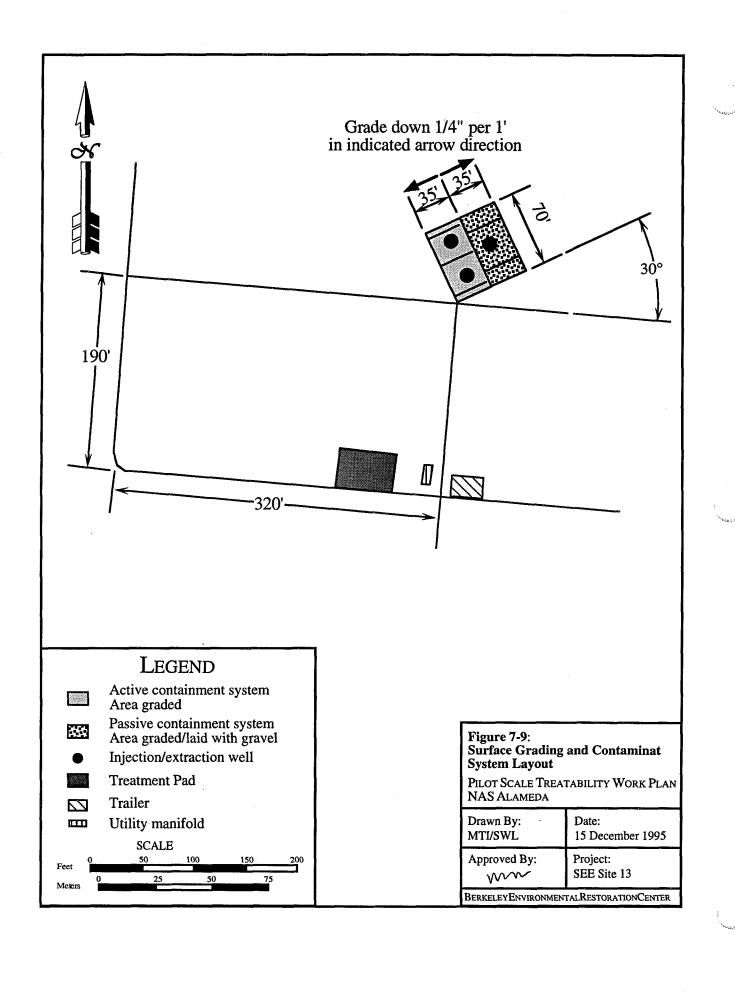
Berkeley Environmental Restoration Center

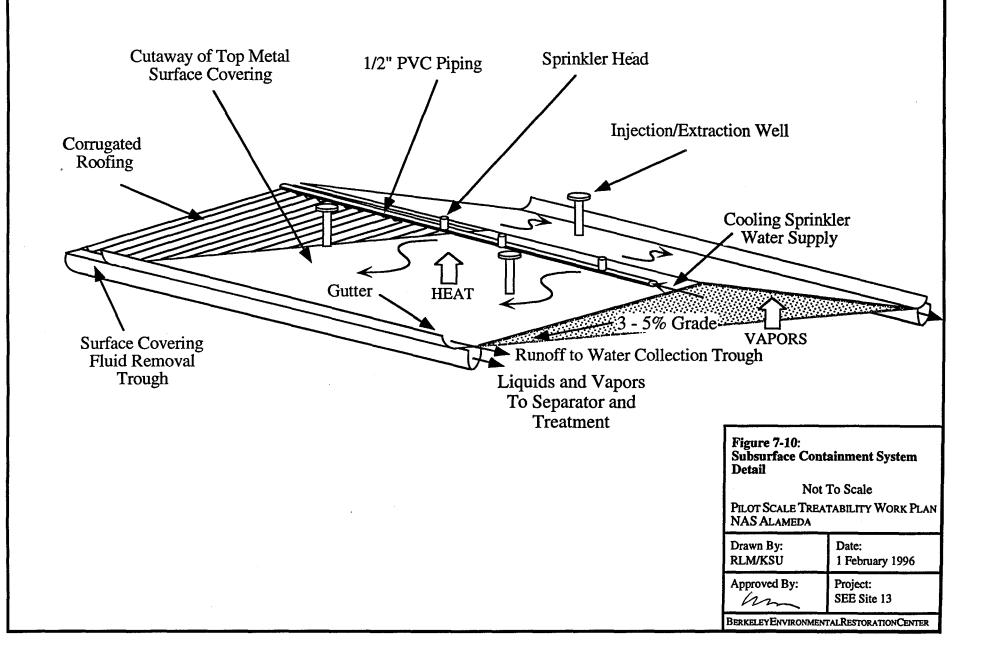


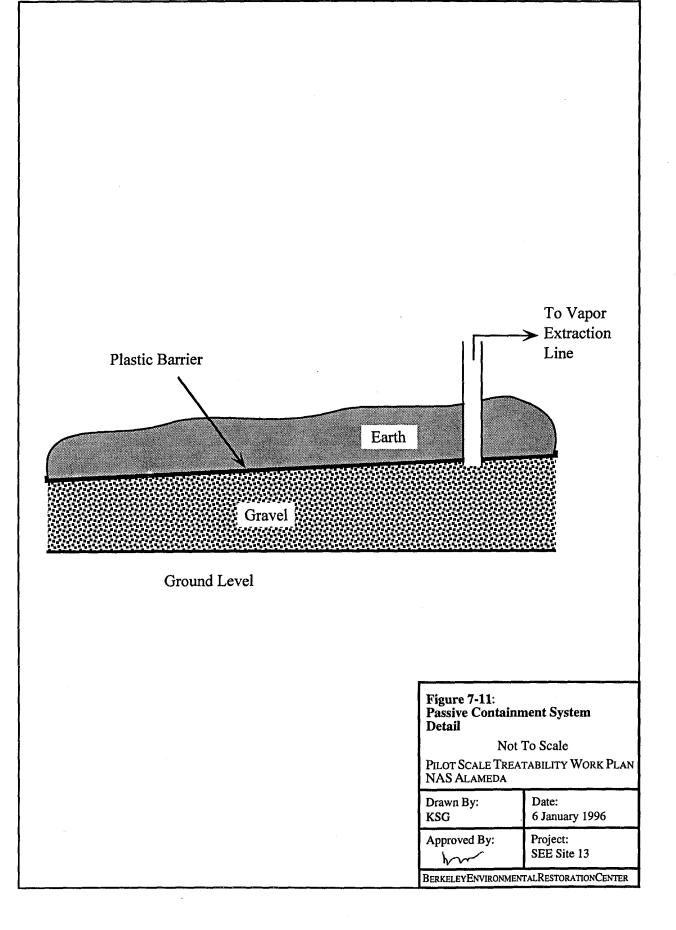


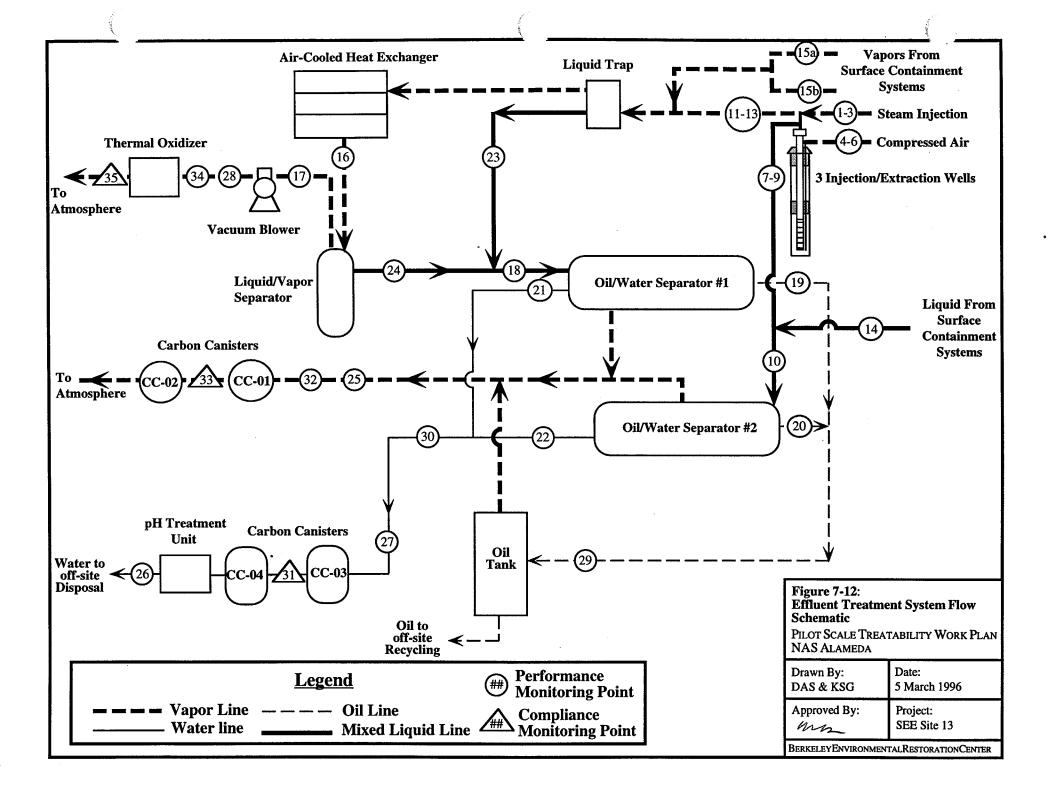












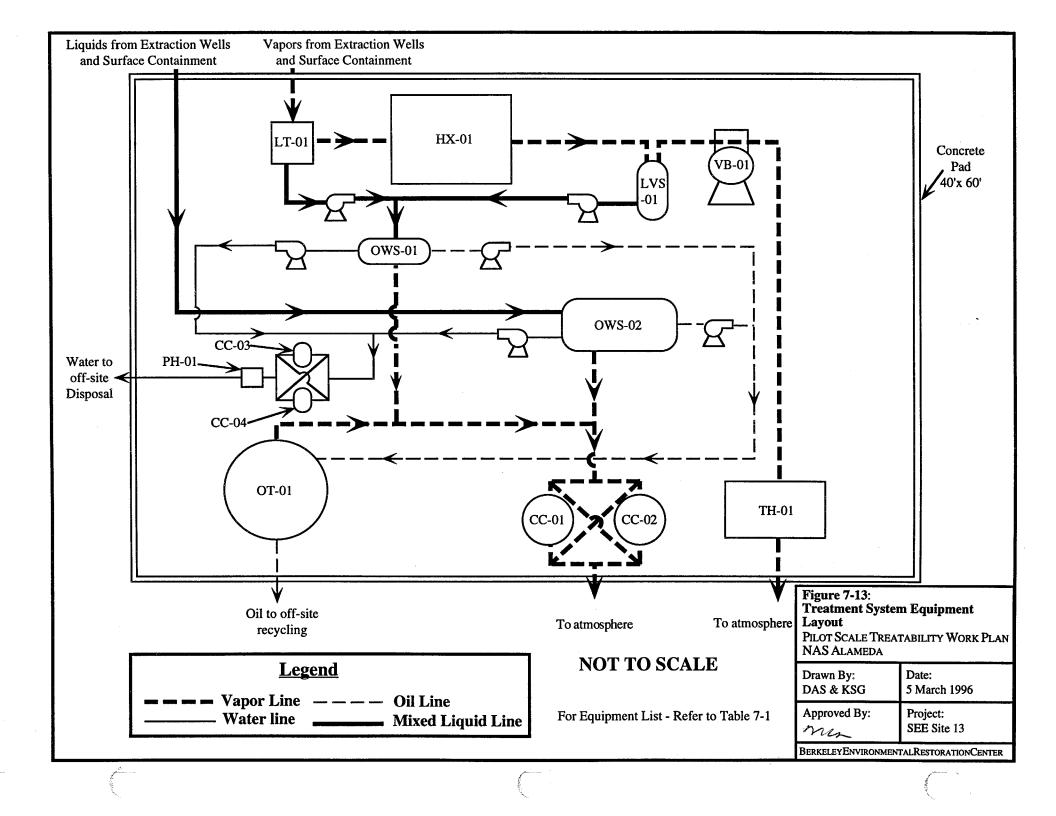


Figure 7-14 Daily Operation Monitoring Log Sheet Three-Well Treatabilty Test Site 13, NAS Alameda

Logged By:		Date:				
		Time:				
		Parameter				
Monitoring		Total Flow	Temperature	Pressure		
Point #	Monitoring Point Description		· •			
Steam Injec	ction Lines					
1	IEW-1					
2	IEW-2					
3	IEW-3					
Compresse	d Air (Pneumatic Pump)					
4	IEW-1					
5	IEW-2					
66	IEW-3					
Liquid Efflu						
7	IEW-1					
8	IEW-2					
9	IEW-3					
10	Sum Liquid Effluent (Includes Surface Cover)					
Vapor Efflue						
11	IEW-1					
12	IEW-2					
13	IEW-3					
14	Liquid Effluent - Surface Cover					
15	Vapor Effluent - Surface Cover					
16	Effluent - Air cooled Heat Exchanger					
17	Vacuum Blower Inlet					
18	Condensate-Liquid Trap & Liquid/Vap. Sep.					
19	Hydrocarbon - Oil/Water Separator #1					
20	Hydrocarbon - Oil/Water Separator #2					
21	Water - Oil/Water Separator #1					
22	Water - Oil/Water Separator #2					
23	Condensate - Liquid Trap					
24	Condensate - Liquid/Vapor Separator					
25	Gas Inlet - Carbon Canisters 1 & 2					
26	Water Effluent - Carbon Canisters 3 & 4					
27	Water Inlet - Carbon Canisters 3 & 4					
28	Inlet - Thermal Oxidation Unit					

Figure 7-15 Temperature Observation Well Monitoring Log Sheet Three-Well Treatabilty Test Site 13, NAS Alameda								
Logged By:			Date:					
Observation Well	Time: Depth, feet				24			
Number	4	8	12 I	16	20			
TMW-1 (IEW-1) TMW-2 (IEW-2) TMW-3 (IEW-3) TMW-4 TMW-5 TMW-6 TMW-7 TMW-8 TMW-9 TMW-10 TMW-11 TMW-12								
TMW-13 TMW-14						 		
TMW-15 TMW-16								

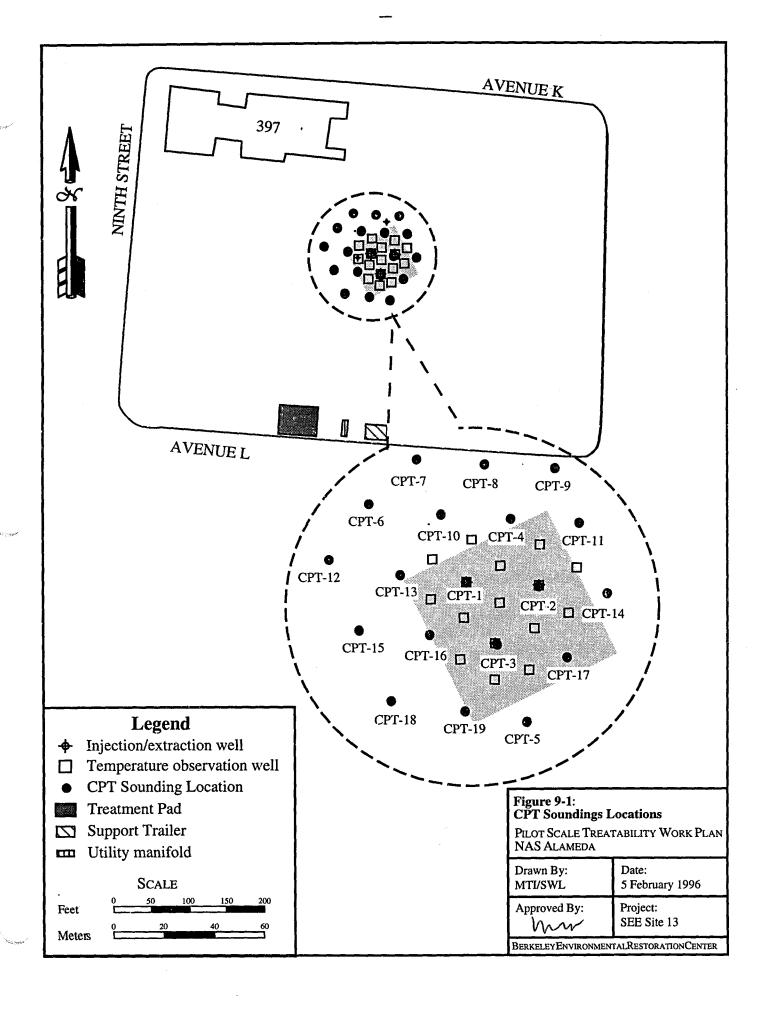


Figure 9-2 Treatability Study Implementation Schedule

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TASK DESCRIPTION	0	1		2 :	3	4	5	6	7	T	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
Notice to Proceed	8		1	ı	l							ĺ														1		ı			i
Design and Subcontractor Procurement							Ĺ					ļ																			i
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Procurement and Contracting	1		***		***		······································		·	***		*****	*****	**************************************	**************************************																į
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Utility Clearance		l			-						-	ı		l	1										•	1					l
Cone Penetrometer Testing			▩	<u> </u>											į	İ	l				1										l
Mobilization of Field-Office Trailer		1	l		***]										İ	1		İ				•						ĺ
Injection/Extraction Well Fabrication]	1		ļ			2									1								l
Temperature Observation Well Fabrication			l	l		·		4	1		ı						1							1							l
Site Surveying and Grading	1		١			*****	1	1	ļ	Į				ĺ	Į .	l										l					ı
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Treatment Equipment Procurement											ı		**************************************	**************************************	,	<u> </u>]					l							l
Treatment Equipment Installation	١			- 1	ı		Ì	Ì			- 1				1		• • • • • • • • • • • • • • • • • • •	**************************************	4		İ	1					l				ĺ
Observation and Monitoring Well Installation			İ		-			1	1		ı			L	J	1	i														-
Temperature Observation Well Installation		l			-						l							1	1						İ	Į.		ŀ			
Electrode Well Installation	1			- 1				1		1					8	l			i			1		1							ĺ
Groundwater Monitoring Well Installation			1				Ī	i		1	- 1			*****	8		1					l					1				
Well Surveying		l	ļ						l		1			l	******					1				İ			1				
Well Development and Sampling	١							1	1						*****	1			1							1					ĺ
Surface Containment installation		•								1	I					:			l												ĺ
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APPENDIX A RESPONSE TO COMMENTS

APPENDIX A

RESPONSE TO COMMENTS

This appendix presents the response to comments received on the draft Pilot-Scale Treatability Study Work Plan submitted on June 30, 1995 for the steam enhanced extraction pilot-scale study to be performed at Site 13 of NAS Alameda. A copy of each comment is reproduced with UCB's response for each comment letter received. The comment letters received were from:

Regina Eng, EFA West
Mary Obland, EFA West
Ken Spielman, EFA West
Bernard Tong, EFA West
Jones Tong, Resident Officer in Charge
IT Corporation
PRC Environmental Management, Inc.
Department of Toxic Substances Control

RESPONSE TO COMMENTS ON JUNE 30, 1995 PILOT SCALE TREATABILITY STUDY WORK PLAN REGINA ENG, EFA WEST 20 MARCH 1996

Comment 1: As requested, reference (b) was reviewed for safety considerations.

Response 1: No response required.

Comment 2: This office provided written comments 21 June 95 on the draft BERC Program Health and Safety Plan dated 8 June 95. Acceptance of Program HSP by this office was dependent upon the health considerations review. Was this review completed? Reference (b) assumes acceptance. Recommend providing a copy of the PHSP to the Code 1825 industrial hygienist (Gilbert Nickelson, x 2577) for review.

Response 2: The June 21, 1995 comments have been addressed in the final program Health and Safety Plan dated October 16, 1995. An over the shoulder review was conducted for this health and safety plan by EFA West and BERC; all comments and concerns on the draft Health and Safety Plan were addressed and the final Health and Safety Plan, Version 3, has been submitted. The health and safety procedures specified in the program plan have been incorporated in to the Site Health and Safety Plan for Site 13, Appendix H of the Work Plan.

Comment 3: Reference (b) as submitted was found unacceptable as a stand alone site-specific supplement to the Program Health and Safety Plan (PHSP). To be acceptable, a copy of the PHSP must be on site and available, and reference (b) be included as a supplement to the PHSP. Without the PHSP, the supplement is not acceptable.

Response 3: The Site Health and Safety Plan, Appendix H of the final Work Plan has been prepared as a stand alone document.

Comment 4: This office recommends that a site-specific HSP be prepared to address the site specific safety and health controls for Site 13 as the PHSP is quite voluminous. The administrative and background information contained within the PHSP that does not directly affect the daily work site safety and health considerations or work processes may be referenced but not the controls to effect safety on the work site. A job hazard analyzes for high pressure steam cleaning (hydroblasting) of field equipment needs to be included.

Response 4: The Site Health and Safety Plan, Appendix H of the final Work Plan, addresses the site specific safety procedures for the three-well treatability test of steam enhanced extraction at Site 13. A job hazard analysis for all site activities, including high pressure steam cleaning, is presented in Section 4 of the Site Health and Safety Plan.

Comment 5: The Workplan SOPs didn't include safety precautions (i.e., required PPE) or reference the applicable PHSP or Appendix C section.

Response 5: The Work Plan references the Site Health and Safety Plan in Appendix H. Required PPE and other health and safety procedures are described specified in the Site Health and Safety Plan which has been prepared as a stand alone document.

RESPONSE TO COMMENTS ON JUNE 30, 1995 PILOT SCALE TREATABILITY STUDY WORK PLAN MARY OBLAND, EFA WEST 20 March 1996

Comment 1: The goal of any work plan is to present an approach rationale and methodology for implementing the work planned in this case a treatability study. Performance specifications are the usual method utilized to achieve this objective. This work plan does not meet the criteria in the sense that there is not enough information for someone to read the work plan and be able to perform the field work and data collection activities. For treatability studies, performance criteria for whether the treatment was effective in order to justify proceeding to the next phase-pilot scale. Standard Operating Procedures need to be revised and finalized to reflect treatability studies. The work plans require job specific information and incorporate references to the appropriate SOP(s) for general information. In addition, provide the methodology and rationale treatment/disposal and illustrate the most cost-effective method for this portion of the process

Response 1: The final Work Plan has been revised to include additional rationale and methodology for field work and data collection activities. Performance objectives for the three-well treatability test and criteria for proceeding to the 15-well pilot scale test are included in Section 7.8 of the final Work Plan. The U.S. Navy will make a decision regarding whether or not to proceed with the pilot-scale treatability study at Site 13 on the basis of the results of laboratory treatability testing described in Appendices B and C of the final Work Plan.

Standard Operating Procedures are currently under revision and will be submitted for review and approval. The final Work Plan includes detailed job specific information and references SOPs as appropriate. The rationale for water treatment/disposal has been included in Section 7.6 of the final Work Plan. The rationale for water/treatment disposal is also described in response 4.

Comment 2: Section 1.0, Page 1, Paragraph 4 - This paragraph should state that these work plans shall be followed, and any modifications shall be addressed via work plan addenda, or memorandum etc.

Response 2: This provision has been added to Section 1 of the final Work Plan.

Comment 3: Section 1.1, Page 2 - The objectives should provide the criteria to determine if the technology is successful. i.e. what is the cleanup goal, in order to determine if this is a cost effective functional remedial technology for this site.

Response 3: Section 7.8 of the final Work Plan includes performance criteria for the three-well treatability test. The data obtained during this test will be used to make a decision whether to proceed with the 15-well pilot scale test. The RI/FS contractor and the U.S. Navy would also use this data to compare the performance of SEE versus other remedial alternatives in subsequent documents, such as an Engineering Evaluation / Cost Analysis (EE/CA) or Feasibility Study (FS).

Comment 4: Section 1.2, Page 2, bullet 5. The use of carbon as a

1

treatment method for the condensate is expensive. Other treatment alternatives shall be addressed including pretreatment prior to polishing by carbon. In addition, all ground water generated from dewatering will also require some pretreatment prior to disposal at a POTW. Ground water reinjection should be evaluated, however treatment standards to drinking water standards may prove more expensive than disposal via a POTW.

Response 4: Section 7.6 of the final Work Plan addresses treatment of the condensed vapors and groundwater. The liquid phase is removed from the vapors in a vapor-liquid separator and the vapors are then treated by thermal oxidation. This method is considered appropriate because the temperature of the gas stream after the compression process within the vacuum blower may exceed the temperature limit of the carbon canisters and the hydrocarbon concentrations in the gas stream are expected to be near saturation due to the elevated temperatures.

Groundwater generated during dewatering will be treated by carbon adsorption prior to discharge to the NAS Alameda wastewater collection system. This method is considered appropriate because of the low levels of hydrocarbons identified in the groundwater. Reinjection of groundwater would involve obtaining permits and this permitting process was not considered appropriate for a short duration project such as the three-well treatability test.

Comment 5: Section 1.3, Page 3, Paragraph 1, Line 7 - the contract number is incorrect - please remedy.

Response 5: This correction has been made.

Comment 6: Section 1.3, Page 3, Paragraph 2 - This paragraph requires significant revision. First, I was under the impression a multiphase approach to determining locations/spacing of test wells would be implemented to reduce costs and errors. A memorandum should be produced between the first phase (3 test wells). and second phase (15 wells) to document most suitable well placement/characteristics. In addition, the work plan should spell out the tasks and how the objectives fit the taskings in the scope of work.

Response 6: The paragraph referenced by this comment has been revised in the final Work Plan. Section 1.4 of the final Work Plan identifies the contractual requirement to prepare a letter report at the completion of the three-well treatability test. Reporting that will be performed for this project discussed in Section 9 of the final Work Plan. The letter report will document the results of the three-well treatability test. Recommendations for well spacing, based on the results of the three-well treatability test, will be made in the work plan for the 15-well pilot scale test if the decision is made to proceed with the next phase of the pilot-scale treatability study.

Comment 7: Section 1.4, Page 3 - this paragraph should only state the names of the various documents referenced in the work plan.

Response 7: This section identifies the program level documents that specify procedures to be followed for the treatability study. As these program documents may be updated in the future, and the most recent version should be consulted by the reader, references to the date of the program documents cited has been deleted.

Comment 8: Section 1.5, Page 4, Paragraph 3 - The SOPs shall be

finalized prior to implementation of the work plan.

Response 8: Standard Operating Procedures are currently under revision and will be submitted for review and approval.

Comment 9: Section 2.2, Page 6, Paragraph 3 - Why is this information included in the work plan? If this information is relevant, i.e. potentially impact the site, additional information as well as references to other documents for additional information on this topic should be provided.

Response 9: This paragraph described a previous spill near the planned treatment area and was included to provide a complete understanding of soil and groundwater quality at and near Site 13 to assess the potential for treatability study activities to affect other areas.

Comment 10: Section 2.3, Page 7, Paragraph 1 - All references to the Conceptual model should be deleted, since this was only intended as an internal document

Response 10: All references to the conceptual model have been deleted in the final Work Plan.

Comment 11: Section 4.0, Page 8, Bullet 1 - The list of chemicals should only include those which are considered chemicals of concern - not every chemical that was detected at the site. For this type of site, it would be highly unlikely that pesticides were disposed of, however they are most likely from legal application for pest control in the area. Please remedy this deficiency.

Response 11: Typically chemicals of concern are identified as part of the risk assessment process. A risk assessment for Site 13 has not yet been performed. In the absence of a risk assessment, all chemicals identified at the site are listed. This information is also important because a chemical may not be of concern on the basis of a risk assessment but may directly affect the application of a remedial technology. For example, metals may not be of a health concern at this site, yet they may interfere with the waste water treatment process and require treatment to prevent difficulties such as scaling.

Comment 12: Section 6.0, Page 9 - Characterization of the site should have been completed by this stage of the RI/FS process. Geostatistics should be applied to demonstrate a need for additional characterization at this site.

Response 12: It was misleading to indicate that the waste oil concentrations had not been fully characterized. Section 4 of the final Work Plan presents a summary of existing soil and groundwater quality at Site 13. The CPT will be performed to provide specific hydrocarbon concentrations in the planned treatment area and to provide vertical delineation of the extent of hydrocarbons. This information will be used to select the placement of the injection/extraction wells and in selecting the appropriate screened intervals for the injection/extraction wells as described in Section 7.1 of the final work plan.

Comment 13: Section 7.2, Page 10 - There should be an explanation of how the mixing of soil with additional sand and packed in a sample holder is representative of site conditions.

Response 13: The laboratory treatability test for total hydrocarbons was primarily intended to determine if the range of thermochemical interactions between steam and

hydrocarbons in soil can result in the removal of hydrocarbons present in soil from Site 13; it is not intended to be representative of field conditions. The three-well treatability test is intended to demonstrate the effectiveness of SEE under field conditions. To simplify the interpretation of laboratory tests we pack our columns with a homogenized blend of site soils and eliminate voids.

Comment 14: Section 8.0, Page 15, Paragraph 1. There is mention of dewatering being required for successful implementation of these work plans. However, there is no analysis of whether dewatering will affect ground water plumes in nearby areas, and if this is technically feasible and cost effective method for remediation of these soils.

Response 14: Aquifer dewatering is addressed in Section 7.3 of the final Work Plan. As described, aquifer dewatering during the first stage of the three-well treatability test will be accomplished by pumping. It is estimated that it will require a pumping rate of 1 gallon per minute to lower the water table by 1 foot at each injection/extraction well. However, the amount of water table depression necessary to enhance recovery of separate phase hydrocarbons can not be estimated until field implementation. The pumping rates will be varied as appropriate.

During subsequent stages of the three-well treatability test, dewatering will be accomplished through displacement by steam. Experience with steam injection, both field and laboratory, has shown that water is displaced by the advancement of the steam zone and thus de-watering can be achieved locally in the steam zone with minimal groundwater extraction as described in Section 7.3 of the final Work Plan. The steam injection pressure must be significantly higher than the local hydrostatic pressure before steam can be injected below the water table, and it is therefore the steam pressure gradient that controls the displacement of the other mobile fluids.

The rate of water extraction from the pilot demonstration cannot be predicted without knowledge of the site permeability. However, at Lemoore, SEE was implemented for 90 days at an average water pumping rate of 13 gal/min. Using this pumping rate and conservatively assuming the thickness of the aquifer and porosity to be at least 10 feet and 0.3 respectively, approximately 500,000 gallons of water would be removed from Site 13 during the three-well treatability test. Under these conditions, groundwater contamination 400 yards away would move less than nine feet toward the pilot demonstration.

Comment 15: Section 9.1.1 - This section should state how often temperature readings will be collected and other data to be gathered, as well as the manner of naming the observation wells from the injection/extraction wells.

Response 15: Section 7.7.1 of the final Work Plan has been added to expand upon the operational monitoring that will be conducted during the three-well treatability test, including the frequency of all operational monitoring to be conducted The manner of naming all wells and samples is identified in Section 12 of the Sampling and Analysis Plan for the Three-Well Treatability Test, Appendix F of the final Work Plan.

Comment 16: Section 9.3, Page 22, Bullet 1 - This is a treatability study to determine if steam enhanced extraction is a viable remedial technology for this site. Characterization is not the intent nor should it be included in this treatability study.

Response 16: As discussed in Response 12, the CPT will be performed to provide

specific hydrocarbon concentrations in the planned treatment area and to provide vertical delineation of the extent of hydrocarbons. This information will be used to select the placement of the injection/extraction wells and in selecting the appropriate screened intervals for the injection/extraction wells as described in Section 7.1 of the final work plan

Comment 17: Section 9.3, Page 22, bullet 6 - All waste generated should be treated on-site not taken to a landfill.

Response 17: On-site treatment of small quantities of waste is generally not economical, at least for heavy oils which require a treatability or field demonstration to show that a proposed treatment method could reduce the hydrocarbon concentrations to acceptable levels. BERC would be willing to work with EFA West, the regulators, and IT to set up a central on-site treatment facility for all oily soils generated by closure activities. An on-site treatment facility relying on bioremediation could provide a valuable bonus because it could provide estimates of the extent to which biological activity could ultimately reduce hydrocarbons in the subsurface and also of the time required for treatment. Such an on-site treatment facility is, however, outside of the scope of the SEE Work Plan.

Comment 18: Section 9.3, Page 23 - SOPs must be finalized and approved by the Navy prior to field work implementation.

Response 18: Standard Operating Procedures are currently under revision and will be submitted for review and approval.

Comment 19: Section 9.3.1, Page 23 - This section should be deleted based on previous comments on the need for additional site characterization.

Response 19: This section described CPT soundings and laser induced fluorescence to be done to characterize hydrocarbon concentrations in the soil prior to the implementation of the three-well treatability test. See response 12 for a discussion of why these activities are necessary prior to implementation of the test. CPT soundings and laser induced fluorescence are described in Section 1 of the Sampling and Analysis Plan for the Three-Well Treatability Test.

Comment 20: Section 9.3.2.1, Page 24 - The paragraph discusses the storage method for drill cuttings. All investigative derived waste should be treated on-site, not disposed in a landfill. Also a staging area for the site should be determined in advance where the investigative derived waste will be placed prior to treatment. The 90 day rule applies unless a CAMU has been previously arranged. Please provide a sample of "appropriate labeling" - especially how the labels will be ensured to remain readable during the period of use.

Response 20: As discussed in response 17, it is generally not cost effective to treat small quantities of waste on-site. All waste will be disposed of off-site within 90 days. Prior to disposal they will be stored at a predesignated staging area within Site 13 as described in Section 12 of the Sampling and Analysis Plan for the Three-Well Treatability Test, Appendix F to the final Work Plan. This section also includes an example of appropriate labeling. Establishment of a staging area is described in Section 8.1.2.1 of the Work Plan.

Comment 21: Section 9.3.10.2, Page 33 - The wastewater treatment method should be the most inexpensive process - the use of activated carbon is considered expensive, especially if the anticipated discharge is to

the base water treatment plant.

Response 21: Based on available groundwater data, the expected hydrocarbon concentrations in the groundwater will be low and direct discharge to the NAS Alameda wastewater collection system may be possible. However, carbon treatment of the recovered water is recommended in the event that elevated concentrations of hydrocarbons are mobilized to the groundwater. Carbon is generally a cost effective treatment for fluids containing low hydrocarbon concentrations.

Comment 22: Section 9.3.10.3, Page 33 - The free product should be sent for recycling, not disposal.

Response 22: Section 7.6 of the final Work Plan and Section 11.2 of the Sampling and Analysis Plan for the Three-Well Treatability Test, Appendix F to the final Work Plan, specify that free phase hydrocarbons will be sent for recycling.

Comment 23: Section 9.3.11, Page 33 - This section is difficult to follow, even more difficult to implement. Examples and summaries of SOPs would assist in implementation. Sample collection activities are not adequately described in order to have reproducible analytical results. Explain decontamination and sampling protocol, where and when, etc.

Response 23: This section described sample handing and analysis. It has been renumbered and revised to better describe sample handling procedures. The new number is Section 14 of the Sampling and Analysis Plan for the Three-Well Treatability Test, Appendix F to the final Work Plan. Decontamination procedures were described in Section 9.3.8 of the draft Work Plan and are described in Section 10 of the final sampling and analysis plan.

Comment 24: Organizational Chart - Delivery Order 003 - The CQC Program Manager must be at the same level as the Program Director in order to implement the quality control/quality assurance process.

Response 24: The draft CQCP included an organization chart that showed the program and project level organization on the same chart. The final CQCP, Appendix D of the final Work Plan, includes an organization chart that shows project level organization. This comment is addressed on the organization chart included in the CQCPP.

Comment 25: Appendix B, Section 1, Page B-4 - The Standard Quality Procedures have not been submitted, nor the final Standard Operating Procedures.

Response 25: Standard Operating Procedures and Standard Quality Procedures are currently under revision and will be submitted for review and approval.

Comment 26: Appendix B, Section 8. 1.3. Page B-7 - ARARs should have already been determined for this site, otherwise how were the criteria for adequate performance of the pilot scale remedial process determined?

Response 26: In the Superfund process, the model being followed at NAS Alameda, ARARs are determined as part of the feasibility study. Therefore, formal determination of ARARs is beyond the scope of this Work Plan. In any case, because of the wide variation in the composition of waste oils from manufacturing processes, cleanup goals for most sites with such waste oils are negotiated based on the local site conditions and the available

remedial technologies. Following this process, then, cleanup goals would be set after the treatability studies were completed, not before.

Feasibility studies at other sites have concluded that the controlling ARAR for similar sites is the Federal non-degradation policy, which require that sources of groundwater contamination be controlled to the best practicable extent. Laboratory treatability testing conducted for this project (see appendices B and C of the final Work Plan) indicate that SEE will not remove appreciable concentrations of total hydrocarbons, but that it is successful in removing the more volatile components and the reducing the leachability of the hydrocarbons left in place. Therefore the performance criteria for the three-well treatability test include the ability of SEE to remove volatile components of the hydrocarbons and to reduce the leachable concentrations of hydrocarbons remaining in the subsurface. These objectives are protective of groundwater quality and meet the objectives of the Federal Nondegradation Policy. These performance criteria are described in Section 7.8 of the final Work Plan.

Comment 27: Appendix B, Section 9.2, Page B-9 - There is no mention of the sampling to be performed as part of the bench scale treatability study. In addition, for the pilot scale treatability study, the sampling and analysis plan does not meet the criteria for obtaining representative, reproducible sampling results.

Response 27: This section of the draft CQCP addressed sampling objectives for sampling to be conducted as part of the field portions of the pilot-scale treatability study. Sampling objectives are now discussed for each phase of the pilot-scale treatability study in the sampling and analysis plans presented in Appendices E and F of the final Work Plan.

Comment 28: Appendix B, Section 9.5 - SOP 18.1 is not included anywhere in this set of work plans. In addition this section references that the number of each type of field QA/QC sample type is specified in Section 9.3 of the work plan - there is no explanation, rationale or table explaining the number of QA/QC samples to be taken.

Response 28: SOP 18.1 was included in the copies of the Work Plan retained by UCB. If it was not in your copy it was a reproduction error. Field quality assurance/quality control samples to be collected are specified in Section 11 of the Sampling and Analysis Plan for the Three-Well Treatability Test and Section 9.3 of the CQCP, Appendices F and D to the final Work Plan. These sections explain the rationale for the number of QA/QC samples collected and analyzed. The expected number of QA/QC samples to be collected and analyzed are specified in Tables 1-2, 2-1, 2-2, 8-1, and 9-1 of the Sampling and Analysis Plan.

Comment 29: Appendix B, Section 9.6, Page B-11 There is no table, chart or other method illustrating what sample collection, preservation and holding times are addressed anywhere in these work plans.

Response 29: Table 9-1 of the draft Work Plan specified sample containers, preservation techniques, and holding times. This table was not reproduced in the draft CQCP because it was referenced in the main text of the draft Work Plan. This table is included as Table 14-1 of the Sampling and Analysis Plan for the Three-Well Treatability Test, Appendix F to the final Work Plan and is not reproduced in the CQCP.

Comment 30: Appendix B, Section 9.7, Page B-12 - A sample collection log is not explained or illustrated anywhere in these work plans.

- Response 30: The sample collection log and its use is described in Section 9.5 of the final CQCP, Appendix D to the final Work Plan.
- Comment 31: Appendix B, Section 9.9, Page B-12 In this section there is mention of a laboratory QA/QC report exactly what will be included as part of this report? Will validation be performed by an independent third party?
- Response 31: Section 9.9 of the draft CQCP has been deleted and laboratory reporting requirements are specified in Section 10 of the final CQCP, Appendix D to the final Work Plan. As specified in Section 10, data validation will be performed by the Project Chemist hired by UCB.
- Comment 32: Appendix B, Section 10.0, Page B-12 No protocol or rationale for sampling is provided in the work plans.
- Response 32: Section 10 of the draft CQCP addressed analytical activities. Sampling rationale and protocol are addressed in the final Sampling and Analysis Plan for Laboratory Treatability Testing, Appendix E to the final Work Plan and the final Sampling and Analysis Plan for the Three-Well Treatability Test, Appendix F to the final Work Plan.
- Comment 33: Appendix B, Section 11.0, Page B-13, Paragraph 3 Data validation shall be performed by an independent third party. Checking numbers is just the beginning.
- Response 33: Section 11 of the CQCP was completely changed with the revision of the CQCP. Data validation is now addressed under Section 10, *Analytical Activities*. As specified in the revised Section 10, the Project Chemist will conduct data validation.
- Comment 34: Appendix B, Section 12, Page B-14 Please provide a summary of requirements including the applicable SOP's and SQP's.
- Response 34: This section of the draft CQCP addressed required reviews of work products by reference to the CQCPP. The text in the final CQCP, Appendix D to the final Work Plan, describes the required technical and peer reviews as well as required procedures for documentation of these reviews. Specific SOPs and SQPs have not been prepared for these reviews.
- Comment 35: Appendix B, Section 14, Page B-14 Please provide a general summary of types of equipment to be used for this project, and the appropriate SOP's/SQP's for calibration and maintenance. In addition, there should be a discussion of calibration before and after use of field equipment.
- Response 35: A general list of equipment to be used for the three-well treatability test has been added to Section 14 of the final CQCP, Appendix D to the final Work Plan. Reference to SQP 8.2, Calibration and Maintenance of Measuring and Test Equipment, has been added to the text. Equipment will be calibrated before and after use, as appropriate.
- Comment 36: Appendix B. Section 15, Page B-14 Specific requirements for controls to be implemented for the performance of the treatability studies should be listed/discussed in this section

Response 36: Specific controls to be implemented to assess the performance of the three-well treatability test are addressed in Section 15 of the final CQCP, Appendix D to the final Work Plan.

Comment 37: Appendix B, Section 15, Page B-l 5 - Which SQP is being referred to?

Response 37: The referenced SQP was 10.2, *Corrective Action*. The text of Section 16 of the final CQCP, Appendix D to the final Work Plan, has been revised to include the correct reference to this SQP.

Comment 38: Appendix B, Section 20, Page B-15 - Section 20 of the CQCPP consists of sections previously described and is therefore redundant.

Response 38: Specific reporting requirements are addressed throughout the CQCP. Section 20 of the CQCP is intended as a summary of reporting requirements to be used as an easy reference. While this is redundant, we have left this section in the final CQCP, Appendix D to the final Work Plan.

Comment 39: This portion of the Work Plans is also missing a significant portion of the information needed in order to evaluate the feasibility of proceeding to the next phase. Information missing includes steam cycling, actual times from collection of sample to analysis, etc. The statement that steam injection will reduce pH in soils must be documented in order to be technically defensible as an alternative treatment option.

Response 39: Appendix C of the final Work Plan includes additional information to enable reviewers to better evaluate the feasibility of proceeding to the next phase of the treatability study, including a discussion of steam cycling and documentation of permissible holding times. Effluent pH levels taken during the first study were reported. These were limited because the study was not designed specifically to measure the effects of steam on pH. More detailed analysis of the pH of the effluent and soil were performed in the laboratory treatability test for leachable hydrocarbons to better characterize this property and are reported in Appendix C.

Comment 40: Page 5, Paragraph 2. Cycling is mentioned yet there is no data to document this process. Please provide this information.

Response 40: Pressure cycling was performed on the one-dimensional experiment after effluent sample 17 was taken. More details of how cycling works and reduces steam requirements are included in the Appendix C of the final Work Plan.

Comment 41: Page 5, Paragraph 4. Please provide clarification of the type and treatment of water utilized for injection. Is distilled in the chemical sense? Why would boiling prior to injection make a difference? Is this process i.e. distilled water, planned to be implemented in the pilot scale portion?

Response 41: The water used was distilled in a stainless steel distillation unit as a precautionary, not required, measure because of the column scale of the experiment. Because the solubility of gasses decreases with increasing temperature, boiling the water before injection reduces the amount of dissolved gasses. Otherwise these gasses would

come out of solution in the sand pack of the experiment. Outgassing is not expected to be a problem in field studies and the NAS Alameda standard procedures for generating steam are expected to be adequate for the field studies.

Comment 42: Page 6, Paragraph 2. This paragraph states that all samples were "sent for analysis within the prescribed holding time" - please state the time elapsed between collection and analysis for each sample sent to the laboratory, in order to document compliance with holding times.

Response 42: Some samples were not analyzed within the holding times, but the samples were refrigerated to retard volatilization and degradation. It has been the BERC practice to send all treatability test samples to the analytical laboratory in one batch to minimize analytical errors associated with differences in laboratory calibrations, chromatographic columns and equipment changes. The samples were not analyzed within the 14 day period specified by the EPA because the experiment ran for a period over twice that time. The degradation from this extended holding time should be of minimal significance because of the high hydrocarbon concentrations identified in the samples and because gas chromatography indicated that the compounds present in the effluent were the higher molecular weight and less volatile hydrocarbons that are more recalcitrant toward degradation.

Comment 43: Page 8, Paragraph 2. Is there analytical evidence to support the hypothesis that arsenic and zinc concentrations have been reduced by steaming?

Response 43: A comparison of arsenic and zinc concentrations in soil before treatment, S0 in Table 4-2, and soil samples taken after treatment (discussed in Appendix B of the final Work Plan) suggest that arsenic and zinc concentrations may have been reduced by steaming.

Comment 44: Page 11, Paragraph 3. Please provide a technical explanation of how and why the pH of the effluent was distinctly different between the beginning and end effluent samples. In addition, please provide a calculation of the actual quantities of water injected into the system, and provide an extrapolation of the amount of water required for the pilot scale treatability study. Also, provide a cost for this water, including the disposal/treatment process, as well as the water obtained from dewatering of the site.

Response 44: The source of the low pH in soils and associated water samples is not known. However, the low pH does show that a readily soluble source of acid constituents is available (recall that pH is a measure of hydrogen ion concentration.). It is very reasonable that steam-treating the oily material in soil extracts the soluble acidic constituents which are then displaced with the soil pore water ahead of the steam front. The efficient, steam enhanced extraction of these constituents then removes the acid-generation potential from these soils, resulting in more neutral pH values for the treated soils; it should also be noted that the organic acids in the oily material are not a likely source of the low pH values as organic acids have pKa values of around 5 (like acetic acid), and the pH due to remaining organic materials is limited by the solubility of these high molecular weight acids.

RESPONSE TO COMMENTS ON JUNE 30, 1995 PILOT SCALE TREATABILITY STUDY WORK PLAN BERNARD TONG, EFA WEST 20 March 1996

Comment 1: p 15. Dewatering site 13 to a depth of 10 feet may cause unnatural groundwater movement and may create a situation where cross contamination between adjacent sites may occur. This possible ill effect has to be addressed.

Aquifer dewatering during implementation of the three-well treatability test is described in Section 7.3 of the final Work Plan. Based on an assumed hydraulic conductivity, it is assumed that a pumping rate of approximately 1 gallon per minute will be required to lower the water table 1 foot at each injection/extraction well. Aquifer testing described in Section 5 of the Sampling and Analysis Plan for the Three-Well Treatability Test will be used to measure the transmissivity and storativity of the water bearing materials at Site 13 and the values obtained will be used to reevaluate the pumping rates required for aquifer dewatering.

The rate of water extraction from the pilot demonstration cannot be predicted without knowledge of the site permeability. However, at Lemoore, SEE was implemented for 90 days at an average water pumping rate of 13 gal/min. Using this pumping rate and conservatively assuming the thickness of the aquifer and porosity to be at least 10 feet and 0.3 respectively, approximately 500,000 gallons of water would be removed from Site 13 during the three well treatability test. Under these conditions, groundwater contamination 400 yards away would move less than nine feet toward the pilot demonstration.

Comment 2: p 33. Waste soil and waste water drums must be labeled. Check 29 CPR regarding requirements and time limitation on the storage and disposal of the drums.

Response 2: Waste soil and waste water drums will be labeled as specified in Table 12-1 of the Sampling and Analysis Plan for the Three-Well Treatability Test, Appendix F of the final Work Plan. Containers containing hazardous wastes will not be stored on-site for longer than 90 days following the start of accumulation of waste.

Comment 3: C-4. "Decontamination/contamination procedures" What is a contamination procedure?

Response 3: References to "contamination procedures" have been deleted from the Site Health and Safety Plan, Appendix H of the final Work Plan.

Comment 4: C-4. Who directs emergency response operation?

Response 4: As specified in Sections 3.6 and 4.15 of the Site Health and Safety Plan, Appendix H to the final Work Plan, the ATG Site Superintendent will direct emergency response operations

Comment 5: C-4. "...an alternate SHSO will be designated and present when the SHSO is not on- site." Has the alternate SHSO been assigned yet at this time? Please keep in mind that the alternate person must have had all the necessary training for a SHSO in accordance with 29 CFR 1910.120 (e) (4).

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Response 5: References to an alternate SHSO have been deleted from the Site Health and Safety Plan, Appendix H to the final Work Plan.

Comment 6: C-4. Job Hazard Analysis. The Laboratory Treatability Test Analytical Results dated August 5, 1995 identified the following metal concentration in the soil samples: Chromium (20 mg/Kg), Copper (110 mg/Kg), Lead (38 mg/Kg), Nickel (21 mg/Kg), and Zinc (57 mg/Kg). The job hazard analysis should include review of the above metal contaminants.

Response 6: Section 4.6.3 of the Site Health and Safety Plan, Appendix H to the final Work Plan includes a complete listing of the chemicals that have been identified at Site 13. The job hazard analysis presented in Section 4 of the plan considers all of these chemicals.

Comment 7: C-14. Should the hospital phone numbers include the off-base prefix numbers?

Response 7: Yes. Off-base prefixes have been included in Section 4.15.3 of the Site Health and Safety Plan because cellular phones or trailer phones which are commonly used in the field are not expected to be part of the base phone system. However, a notation has been added to Section 4.15.3 regarding the number to be dialed from base phones.

Comment 8: C-14. Has the hospital been contacted to make sure that the hospital can handle contaminated patients?

Response 8: No. The hospital has not been contacted regarding contaminated patients. Individuals requiring hospitalization will be decontaminated before hand. See next response.

Comment 9: C-14. What is your emergency decontamination procedure?

Response 9: Emergency decontamination procedures are identified in Section 4.12.5 of the Site Health and Safety Plan, Appendix H to the final Work Plan.

Comment 10: C-15. Should the 911 numbers include the off-base prefix numbers?

Response 10: See response 7.

Comment 11: C-16. General safe work practices, third item: "Gross decontamination and removal of all disposable personal protective equipment shall be performed prior to exiting the EZ area" This is in violation of the OSHA rules. Decontamination should be done outside the EZ and in the CRZ area.

Response 11: Section 4.12 of the Site Health and Safety Plan, Appendix H to the final Work Plan, states that decontamination will take place in the CRZ.

Comment 12: D-2. Second paragraph, last sentence: "Additionally, two trailers, supporting the contractor's work force, will be placed within the fenced area" Again, check OSHA rules.

Response 12: Section 4.9.6 of the Site Health and Safety Plan, Appendix H to the final Work Plan, specifies that the office trailer will be set up in the support zone.

After reviewing the Laboratory Treatability Test Analytical Results dated August 5, 1995, I have the following questions/comments:

Comment 13: The contaminated soil samples were taken using a hand auger. It would be safe to assume they were taken from the top dry layer only. We know that the water table at the site is about five feet below. Are we/they going to take some soil samples below the water table and test the SEE technology?

Response 13: The soil samples were taken from beneath the water table in a region of high hydrocarbon concentrations.

Comment 14: The report indicated that the PAH analysis conducted could not draw any conclusions regarding the presence or absence of compounds of health concern. What is the recommendation for a more definitive finding.

Response 14: Appendix C to the final Work Plan describes the laboratory treatability test for leachable hydrocarbons. The sampling included more extensive analyses to further characterize the effects of steam on PAHs.

Comment 15: The report suggests the possibility that after removing about 20% of the hydrocarbon contamination and restoring the site to neutral pH through application of SEE at a modest cost, the changes may effect the biodegradation rate enough to allow the process to clean itself up without further processing. Even if the above is true, the conclusion can apply only to the top soil layer above the water table since the results of the SEE technology has not been tested on the water saturated soil samples.

Response 15: Soil samples were taken beneath the water table, so the SEE technology has been tested on the water saturated soil samples. This will be further tested during the three-well treatability test.

Comment 16: The test results showed no change in the level of metal concentration with the exception of mercury concentration, which showed significant reduction. There were no followup recommendations made in the report regarding the removal of metal concentration.

Response 16: Table 4-2 of Appendix B to the final Work Plan shows that metals concentrations decreased in the steam treated soil samples during the laboratory treatability test for total hydrocarbons. Metals do not appear to be a problem at the site. However, the laboratory treatability test for leachable hydrocarbons, described in Appendix C to the final Work Plan, included waste extraction tests for metals to address the leachability of metals remaining in the soil after the application of steam.

RESPONSE TO COMMENTS ON JUNE 30, 1995 PILOT SCALE TREATABILITY STUDY WORK PLAN KEN SPIELMAN, EFA WEST 20 March, 1996

Comment 1: Sample preparation and laboratory test conditions are not representative of field conditions and, thus, cannot provide applicable results for *in-situ* testing. The field application of SEE at Site 13 will have many variables (i.e. mobilization of contaminants, groundwater flow due to dewatering, radius of influence, removal of surface vapors) that should be under control or, at the very least, fully studied in bench scale tests. Based upon your experience, describe in the work plan the measures that will be taken to modify the SEE process from the lab tests to field wells.

Response 1: The laboratory treatability test results described in Appendix B and C of the final Work Plan clearly and unambiguously showed that SEE will be unable to remove the majority of the heavier components of the waste oil at Site 13. To simplify the interpretation of the laboratory treatability tests we packed the soil column with a homogenized blend of site soils and sand to eliminate void spaces and promote uniform flow of steam through the column. We also run at an increased pressure to shorten the duration of the test. While these conditions are not representative of field conditions, they provide an evaluation of the ability of SEE to remove the most volatile hydrocarbons through steam distillation.

The laboratory treatability test for leachable hydrocarbons described in Appendix C of the final Work Plan evaluated the potential of SEE to remove the components of the hydrocarbons present at Site 13. This test more closely simulates field conditions and was operated with a maximum pressure cycle of 10 psig, a value that simulates field conditions, and for a shorter time than the first treatability test.

The laboratory treatability tests adequately simulates one of the two primary mobilization mechanisms for contaminants in the field, steam distillation. Mobilization via steam distillation depends on the properties of steam and the hydrocarbons, which are the same in the laboratory and in the field.

The other primary mobilization mechanism for contaminants in the field, mobilization through viscosity reduction and gravity forces is best simulated via the three-well treatability test. This mobilization mechanism, which depends on the flow of liquids rather than gaseous vapors, is more sensitive to the influence of subsurface heterogeneities than steam distillation. Heterogeneities in the subsurface are on a scale of many feet and are very difficult to simulate in laboratory studies. The smallest dimension of our laboratory soil columns and beds, on the order of a few inches, is too small to accurately simulate field heterogeneities. The influence of subsurface heterogeneities is most directly and effectively evaluated by small field studies, such as the three-well treatability test.

Other variables listed by the reviewer, including groundwater flow due to dewatering and radius of influence, also depend on subsurface heterogeneities, are important in determining well spacing, and are nearly impossible to simulate realistically in the lab. Aquifer dewatering is addressed in Section 7.3 of the final Work Plan.

Removal of surface vapors relies on surface cover technology that has frequently been applied to enhance the efficiency of soil vapor extraction technologies. Testing of surface cover technologies is not possible during small scale lab tests such as those performed for

the pilot-scale treatability study. For the three-well treatability test, BERC will rely on the field experience gained in the construction and maintenance of surface covers to design and build the surface covers at this site. The two surface containment systems that will be tested during the three-well treatability test are described in Section 7.5 of the final Work Plan.

Comment 2: Quantitative objectives which are integral to the decision-making process and are necessary for the determination of when or if to proceed to the next phase, must be fully described. Goals for contaminant removal times and levels are a valuable tool for the evaluation and communication of results.

Response 2: The objectives of the three-well treatability test are described in Section 1.1 of the final Work Plan. Goals for contaminant removal during the three-well treatability test and the decision criteria for proceeding to the 15-well pilot-scale test are described in Section 7.8 of the final Work Plan. The data from either field test could be used by the RI/FS contractor and the Navy to either set clean-up levels or to evaluate whether clean up levels based on other considerations, for example risk, can be met. If SEE is not able to reduce contaminant concentrations to the clean up levels chosen for the site, the process may alter subsurface conditions and contaminant concentrations such that the site would be more amenable to another clean up process such as enhanced bioremediation. The possibility of this would be discussed in the letter report submitted at the completion of the three-well treatability test.

Comment 3: Additional design and process information is necessary for proper evaluation of field operations and waste treatment. The volumes of vapor and liquid to be extracted as well as rates of extraction determine the required capacity of the operation. The flow diagram (Figure 8.8) must indicate flow rates and unit equipment capacities. The results of a Bench-scale test would provide estimates for volumes and rates of extraction process.

Response 3: The expected volumes of liquid and vapor effluents are addressed in Sections 7.3 and 7.6 of the final Work Plan. Table 7-1 of the final Work Plan specifies the treatment equipment that will be used as well as the required capacity of each piece of equipment. These rates are based on an assumed hydraulic conductivity for the site. Aquifer testing described in Section 5 of the Sampling and Analysis Plan for the Three-Well Treatability Test (Appendix F of the final Work Plan) will be used to provide a better estimate of the transmissivity and storativity of the water bearing materials. The values obtained will be used to revise our estimates of flow rates and the specified sizes of the treatment equipment prior to procurement and installation of the equipment.

RESPONSE TO COMMENTS ON JUNE 30, 1995 PILOT SCALE TREATABILITY STUDY WORK PLAN JONES TONG, RESIDENT OFFICER IN CHARGE 20 March 1996

Comment 1: Referenced SOPs and SQPs not included in the CQCPP submitted in June 95.

Response 1: The current version SOPs and SQPs are being prepared as separate documents and will be submitted for review and approval.

Comment 2: Figure B-1: The project organization chart indicated the QC functions are subordinate to the E2 project manager which is not allowed; the QC should be independent and work under the UC CQC program manager with all QC related functions under the project CQC manager separate from the construction production effort. The chart should also identify the necessary submittal reviewer and approval requirements, testing labs and consultants related to QC.

Response 2: The organization chart has been revised in response to this comment. Program and project organization charts are provided on Figures 2-1 and 2-2 of Contractor's Quality Control Plan (CQCP), Appendix D to the final Work Plan.

As described in Section 2 of the CQCP, a separate project management submittal will be prepared to identify subcontractors to UCB (including testing laboratories) and individuals assigned to the project. Submittal review and approval requirements are addressed in Sections 6 and 12 of the CQCP.

Comment 3: 'Missing appointment letter for QC Manager including QC manager's authority.

Response 3: An appointment letter for the Contractor Quality Control Manager will be included in the separate project management submittal to the Navy.

Comment 4: No procedures for reviewing, approving and managing submittals, no submittal register.

Response 4: Procedures for managing project documents, including a submittal register, are contained in Section 6 of the CQCP, Appendix D to the final Work Plan.

Comment 5: No testing plan and log that includes the tests required, type of test and frequency and the person responsible for the test.

Response 5: A testing plan and log is provided in Figure 15-1 of the CQCP, Appendix D to the final Work Plan.

- Comment 6: No listing of outside organizations with description of services these firms will provide.
- Response 6: The project organization, including a description of some services that will be provided by outside organizations, is discussed in Section 2 of the CQCP, Appendix D the final Work Plan. As discussed in Section 2, Subcontractors to UCB will be identified in a separate project management submittal to the U.S. Navy prior to the start up of field work.
- Comment 7: Definable feature of work must include three phases of inspection and control requirement.
- Response 7: A definable features of work matrix is presented on Figure 13-1 of the CQCP, Appendix D to the final Work Plan. The three phases of inspection and control for each definable feature of work are described in Section 13 of the CQCP.
- Comment 8: Testing laboratory must be from acceptable accreditation programs or be approved by the government, requirements must be submitted for review prior to approval.
- Response 8: As specified in Section 10 of the CQCP, Appendix D to the final Work Plan, laboratories used for the treatability studies will be certified by the Facilities Engineering Service Center and the California Environmental Protection Agency, unless otherwise approved by the Navy.
- Comment 9: No documentation procedures for report submittal, (i.e.: daily QC and production report to be submitted by 10 am the next day, QC meeting minutes to be submitted 2 days after meeting, and others ...)
- Response 9: Section 20 of the CQCP, Appendix D to the final Work Plan, summarizes the reporting requirements for this project and includes documentation procedures for the submittal of each report.

IT STUDY WORK PLAN IT CORPORATION 20 March, 1996

Comment 1: In our review of the previous draft of this Work Plan. dated April 17, 1995, IT presumed the technical feasibility of the Steam Enhanced Extraction (SEE) process had been demonstrated in the laboratory treatability tests. Accordingly, our comments dated May 17, 1995 were of a specific, "paragraph by paragraph" nature. Some of these specific comments have been appropriately addressed in the current draft of the Work Plan; however, several others have not been addressed.

Response 1: Noted

Comment 2: After receiving the June 30 draft of the Work Plan, in particular Appendix A, "Laboratory Treatability Test Analytical Results," IT suggests that two very basic concerns should be resolved before proceeding with field implementation of the SEE technology; therefore, specific comments on the current Work Plan are not offered. Instead, the two basic concerns mentioned above are presented.

Response 2: Noted

Comment 3: Our first concern is that, contrary to our earlier presumption, the laboratory treatability tests do not demonstrate the feasibility of the SEE technology. The laboratory test sample, apparatus, and operating conditions differ significantly from the conditions which will be encountered in the field. The key differences are outlined in Table 1. In general, the laboratory conditions are more conducive to attaining favorable process performance than the field conditions; however, the laboratory tests provided only a 25 percent reduction of the total petroleum hydrocarbon (TPH) concentration in the soil.

Response 3: We agree with IT that the laboratory treatability tests show that the SEE technology is unlikely to remove more than 25 percent of the hydrocarbon mass found at Site 13. Theoretical considerations and the results of the laboratory treatability test for total hydrocarbons indicate, however, that the hydrocarbons removed are the more volatile hydrocarbons which would generally be more leachable to the groundwater. Potential health and environmental risks could be reduced by removal of this fraction of the hydrocarbon mass. The Navy and the regulatory agencies would need to determine if the residual levels of hydrocarbons present in the soil would present acceptable health risks or if there are other technologies which could cost effectively remove a larger portion of the hydrocarbons. Based on the low volatility and the viscous nature of major portion of oily material present in the subsurface, available and technically viable remedial options for total hydrocarbon removal are limited for Site 13. Also, application of SEE to remove the more volatile hydrocarbons may leave the site more amenable to other treatment methods such as enhanced bioremediation.

The objectives of the laboratory treatability test for total hydrocarbons were to characterize both the residual oil remaining in the soil after the application of steam and the hydrocarbons removed through sampling and analysis of the effluent. To facilitate interpretation of the results, a one dimensional test was performed under conditions that are not necessarily directly representative of the field. As IT pointed out, simulation of the flow

of any liquid, including steam, through a heterogeneous subsurface in the laboratory is extremely difficult.

Table 1 appears to misinterpret the purpose of the laboratory treatability studies compared to the field applications of SEE. The laboratory study only simulates the interaction of steam with site soil for removing hydrocarbon components from the soil. The laboratory results are then applied to the design of the field study in terms of the amount of steam that is required to achieve hydrocarbon removal, the achievable reporting limits, and the analytical program that is then usefully implemented. Indeed, both laboratory treatability studies have been valuable in scoping the field test program, which is now focused on removing the BTEX and more volatile fraction of hydrocarbon and not on total hydrocarbons as analyzed by the entire TPH suite. PAHs are likely present, but at concentrations below the reporting limits. Also, while 30 psig may not be attainable on a large field scale, the 10 psig used in the laboratory treatability test for leachable hydrocarbons is attainable in a treatment zone. The pressures and temperatures in the treatment zone will be measured during the three-well treatability test. The intent of the three-well treatability test is to characterize steam flow through a heterogeneous subsurface and test the ability of steam to upwardly mobilize separate phase hydrocarbons from the subsurface under field conditions.

Laboratory identification of PAHs in a heavy oil matrix is difficult without special extraction methods to eliminate background interference and provide lower detection limits. To allow better identification of PAHs in soil samples from Site 13, BERC is discussing modifications to standard analytical procedures with several laboratories, including some with considerable experience in analyzing for PAHs in soils containing coal tars.

Comment 4: This 25 percent reduction was attributed primarily to removal of the lighter diesel fuel fraction of the TPH and was attained over 45 days at a projected cost of \$100/yd³ (based on the cost of steam at Alameda NAS). Commercially proven technologies which will yield an 85-95% reduction are available at a comparable total cost.

Response 4: We are aware of no commercially proven technologies, other than incineration, that are capable of removing 85 to 90 percent of heavy oils from a soil matrix. The methods IT are referring to may be *ex-situ* treatment methods. However, extensive and expensive dewatering and shoring of the site would be required to excavate the soils for *ex-situ* treatment.

Comment 5: IT's second concern is that there do not appear to be any provisions to install and sample a comprehensive monitoring well network during the treatability test or pilot test operations. It is essential to ensure the SEE process does not spread the dissolved phase plume. The plume contains several toxic and/or carcinogenic compounds. IT believes the treatability test system should not be constructed until provisions are made to effectively monitor groundwater.

Response 5: Maintenance of proper steam pressures within the steam zone and adequate pumping of liquids during the field treatability and pilot-scale tests should provide adequate measures to prevent the spread of the dissolved phase plume beyond the boundaries of Site 13. Regardless, Section 7.4 of the final Work Plan includes provisions for installing four groundwater monitoring wells to monitor groundwater outside of the treatment area.

Table 1
Comparison of Laboratory vs. Field Parameters for the SEE Technology

Laboratory Test Parameters	Field Parameters
Soil is homogenized	Soil is non-homogenous
Process has adiabatic control	Process is not adiabatic
Soil/Steam are contained; no possible lateral steam movement	No restraint against lateral movement of steam
Soil is packed and compressed to minimize channeling	Differing permeabilities of heterogeneous soils will allow channeling
Column is pressured to 30 psig to get higher temperatures "to mobilize contaminants in crevices"	Pressurization to attain higher temperatures is not readily viable in the field
No PAH's in soil sample	PAH's are a known contaminant

RESPONSE TO COMMENTS ON JUNE 30, 1995 PILOT SCALE TREATABILITY STUDY WORK PLAN PRC ENVIRONMENTAL MANAGEMENT, INC. 20 March 1996

Comment 1: The Pilot Scale Treatability Work Plan (Work Plan) set forth only qualitative objectives through general statements made in the paragraph under Section 1.1. The qualitative objectives are clearly stated, and are appropriate, but to conduct a treatability study that will allow the decision to use a technology at full scale, endpoints that are at least semi-quantifiable must be set forth at the beginning of the study. Without statement of quantifiable endpoints, there is no way to evaluate success, and the type of information needed to support a costly decision is lacking.

Response 1: Performance criteria for the three-well treatability test are included in Section 7.8 of the final Work Plan with criteria for proceeding to the 15-well pilot-scale test. These goals include the removal of the more volatile components of the hydrocarbon mixture and reducing the leachability of the hydrocarbons left in place. Based on data from the three-well treatability test, quantitative goals for a 15-well pilot-scale test can be set with a high degree of technical certainty if the decision is made to go ahead with this phase of the treatability study.

Comment 2: Setting objectives does not only include statements regarding analytical data quality, but also includes such information as that regarding the expected effectiveness of contaminant removal, the efficiency of the system, or ability to handle all waste generated during the action. For pilot scale tests, the cost of conducting the test can be significant, and it is important to impose fairly rigorous quality control objectives on the study; information about whether a technology can meet an expected cleanup criteria, or how it may compare to the effectiveness/efficiency of other treatment alternatives is needed to make decisions that affect the development of the record of decision.

Response 2: As discussed in Section 1 of the final Work Plan, laboratory testing conducted on soil from Site 13 indicates that SEE may not be capable of removing an appreciable mass of total hydrocarbons from the soil. However, the laboratory tests indicate that SEE is capable of removing the more volatile components of the hydrocarbon mixture and reducing the leachability of the hydrocarbons left in place. Other available treatment technologies for the highly viscous hydrocarbons at Site 13 are limited and excavation may be the only alternative capable of removing all of the hydrocarbons in a reasonable time frame. Another treatability study is being conducted by UCB to evaluate whether intrinsic bioremediation is capable of removing the hydrocarbons present at this site within a reasonable time frame.

In the absence of available and cost effective technologies that may achieve total removal of hydrocarbons, data from the pilot-scale treatability study should provide an indication of technically feasible clean up objectives. As discussed in response 1, Section 7.8 of the final Work Plan includes performance objectives for the three-well treatability test, including the removal of volatile hydrocarbons and reducing the leachability of the hydrocarbons left in place. The RI/FS contractor and the Navy would then use this data to compare the performance of steam enhanced extraction versus other alternatives in subsequent documents, such as an Engineering Evaluation/Cost Analysis (EE/CA) or Feasibility Study (FS). If SEE is not able to reduce contaminant concentrations to the clean up levels chosen

for the site, the process may alter subsurface conditions and contaminant concentrations such that the site would be more amenable to another clean up process such as enhanced bioremediation. The possibility of this would be discussed in the letter report submitted at the completion of the three-well treatability test.

Quality control procedures to be followed for the three-well treatability test are included in the Contractor's Quality Control Plan in Appendix D of the final Work Plan. Methods for handling the treatability study wastes are described in Section 11 of the Sampling and Analysis Plan for the Three-Well Treatability Test in Appendix F of the final Work Plan.

Comment 3: The Work Plan should set forth quantitative bench scale objectives. While the text indirectly indicates there is a possibility of removing 99% of the oily contaminants in the soil, a more definitive statement needs to be made. Without setting a quantitative goal, the decision to mobilize to the field to conduct the 3 well study cannot be made with confidence. This could be costly and an inefficient use of time.

Response 3: Any reference in the text indicating, even indirectly, that the steam enhanced extraction process could remove 99% of the oily contaminants found at Site 13 was erroneous. On other projects, the SEE process has been demonstrated to remove extremely high percentages of gasoline, diesel, and jet fuels. Results of the laboratory treatability tests for this project indicate that at Site 13, the lighter and more volatile hydrocarbons are removed by the application of steam. The SEE process is not expected to remove a measurable fraction of the total mass of heavy and relatively inert hydrocarbons.

As stated in Section 7.8 of the final Work Plan, implementation of the three-well treatability test will provide data to assess the ability of subsurface materials at Site 13 to transmit steam, the ability of SEE to recover free phase hydrocarbons under field conditions, and the ability of SEE to remove hydrocarbons from the subsurface through steam distillation. In the absence of available and cost effective technologies that may achieve total removal of hydrocarbons, data from the pilot-scale treatability study should provide an indication of technically feasible clean up objectives as discussed above.

Comment 4: Likewise, quantitative goals must be established for the 3 well study as well as the scaled up 15 well study. This Work Plan did not establish quantitative goals. Objectives that should be set include the percent removal expected, the anticipated soil concentration remaining upon completion, estimates of the maximum contamination expected in any effluent from the study, volumes of waste anticipated, and quantitative goals that trigger decisions to discontinue the study if necessary. This information is not provided in the Work Plan.

Response 4: Performance criteria for the three-well treatability test are described in Section 7.8 of the final Work Plan with criteria for proceeding to the 15-well pilot scale test. The 15-well pilot scale test would be justified if 1) the three-well treatability test is successful at reducing hydrocarbon concentration in the effluent to one or two orders of magnitude lower than the initial concentrations identified in the effluent; and 2) the three-well treatability test is successful at removing the more volatile components and the leachability of the hydrocarbons remaining in the subsurface. The Navy and regulatory agencies will be given an opportunity to review the results of the three-well treatability test to decide whether the results justify proceeding to the next test.

Estimates of maximum concentration of contaminants in effluents from the three-well treatability test are addressed in Section 7.6.

Comment 5: Pumping of the Aquifer. This treatability study assumes that the aquifer will be dewatered by at least 6 feet over an extended period of time while the tests are conducted. The first test will run for 30 days, and the scaled up test will run for 180 days. Dewatering the aquifer for extended periods of time could produce consequences which are not discussed or planned for in this treatability study Work Plan. Such pumping of the aquifer could lead to capturing contaminant plumes from sites nearby Site 13, for example, Site 19. Also, there are no provisions in this Work Plan for managing the water that will be pumped from the aquifer. This issue should be more clearly defined and discussed before proceeding.

Response 5: Aquifer dewatering is addressed in Section 7.3 of the final Work Plan. As described, aquifer dewatering during the first stage of the three-well treatability test will be accomplished by pumping. It is estimated that it will require a pumping rate of 1 gallon per minute to lower the water table by 1 foot at each injection/extraction well. However, the amount of water table depression necessary to enhance recovery of separate phase hydrocarbons can not be estimated until field implementation. The pumping rates will be varied as appropriate.

During subsequent stages of the three-well treatability test, dewatering will be accomplished primarily through displacement by steam. Experience with steam injection, both field and laboratory, has shown that water is displaced by the advancement of the steam zone and thus de-watering can be achieved locally in the steam zone with minimal groundwater extraction as described in Section 7.3 of the final Work Plan. The steam injection pressure must be significantly higher than the local hydrostatic pressure before steam can be injected below the water table, and it is therefore the steam pressure gradient that controls the displacement of the other mobile fluids.

The rate of water extraction from the pilot demonstration cannot be predicted without knowledge of the site permeability. However, at Lemoore, SEE was implemented for 90 days at an average water pumping rate of 13 gal/min. Using this pumping rate and conservatively assuming the thickness of the aquifer and porosity to be at least 10 feet and 0.3 respectively, approximately 500,000 gallons of water would be removed from Site 13 during the three-well treatability test. Under these conditions, groundwater contamination 400 yards away would move less than nine feet toward the pilot demonstration.

The treatment system for the water that will be produced during dewatering is described in Section 7.6 of the final Work Plan. The system is capable of handling liquid flows up to 50 gallons per minute which should accommodate the various pumping schemes that may be necessary to achieve dewatering of the aquifer.

Comment 6: During this treatability study, the waste stream being generated during the aquifer testing could be of significant quantity. However, the Work Plan does not address the volume of this waste stream, or how it will be managed.

Response 6: Section 5 of the Sampling and Analysis Plan for the Three-Well Treatability Test, Appendix F to the final Work Plan addresses the expected volume of water to be produced during aquifer testing and includes a provision for containerizing and sampling the liquid prior to discharge to the treatability study effluent treatment system.

Comment 7: The volume of waste water anticipated from vapor

condensate, and from "liquid recovery" during the injection/extraction process is not defined.

Response 7: One purpose of the three-well treatability test is to define the in situ permeability of the water bearing materials at Site 13. Without knowledge of the in situ parameters, no accurate estimates of above-ground process stream flow volumes can be made. Expected flow rates are addressed in Section 7.6 of the final Work Plan.

Comment 8: The number of carbon canisters needed, and being generated as waste during the test is not defined

Response 8: We will start with six 42 gallon drums of carbon during the three-well treatability test; three for the treatment of vapors from the oil/water separators and the oil storage tank and three for the water treatment. More canisters will be delivered as necessary on a schedule determined by the usage rate. Use and cycling of the carbon canisters is addressed in Section 7.6 of the final Work Plan.

Comment 9: The soil cuttings generated during the soil boring and well drilling are proposed for disposal. Because the soil will contain the same contaminants as the soil in the subsurface being treated during this treatability study, perhaps UC Berkeley should consider treating the soil cuttings in a container ex-situ.

Response 9: On-site treatment of small quantities of waste is generally not an economical disposal method, at least for heavy oils which require a treatability or field demonstration to show that a proposed treatment method could reduce the hydrocarbon concentrations to acceptable levels. BERC would be willing to work with EFA West, the regulators, and IT to set up a central on-site treatment facility. An on-site treatment facility relying on bioremediation could provide a valuable bonus because it could provide estimates of the extent to which biological activity could ultimately reduce hydrocarbons in the subsurface and also of the time required for treatment. An on-site treatment facility is, however, outside of the scope of the SEE Work Plan. Treatment of cuttings in a container *ex situ* may be considered if evaluation of biotreatment options is added to the scope after the three-well treatability test.

Comment 10: Section 1.0, Introduction, Page 1. The sentence at the end of the second paragraph states that there is a requirement to perform in situ tests prior to a record of decision. This in incorrect; it is recommended such tests be performed.

Response 10: The text has been changed as noted.

Comment 11: Section 2.3, Previous Investigations, Page 6. There are now a total of 63 soil borings and 13 wells. There are also two new reports as follows:

- Remedial Investigation/Feasibility Study Data Transmittal Memorandum, Sites 4, 5, 6, 8, 10A, 12, and 14, May 1995
- Remedial Investigation/Feasibility Study Data Transmittal Memorandum, Sites 1, 2, Runway Area, 3, 5, 6, 7A, 7B, 7C, 9 10B, 11, 13, 15, 16, and 19, July 1995.

The reference to the Remedial Investigation/Feasibility Study Site

Conceptual Models should not be cited. This document was not a formal deliverable to the Navy, and was intended for a meeting discussion only. Therefore, it is not in the administrative record, and cannot be cited. Please remove all references to this document.

Response 11: Section 2.3 of the final Work Plan has been revised to include the updated information and UCB has received a copy of the above reports from the Navy. References to the *Remedial Investigation/Feasibility Study Site Conceptual Models* have been deleted as requested. Sections 3 and 4 also address the updated information.

Comment 12: Section 7.2, Soil Sample Preparation, Page 11. It is unclear whether the bench scale study will simulate field conditions, because the text indicates that the sample will be compacted to minimize voids; further, the text states that "voids are undesirable since they compromise the homogeneity of the one-dimensional sand pack and could lead to uneven steam flow." The text on page 13 indicates that the pressure in the sample holder will rise to about 30 pounds per square inch, gas. Do these pressures simulate what will occur in the field test? If not, then how does bench scale data help determine whether a pilot scale test will work?

Response 12: The laboratory treatability tests described in the draft Work Plan were designed to provide clear, unambiguous results regarding leachability, steam distillation rates, and pH variations during SEE application to the site soil and waste oil. To simplify the interpretation of laboratory tests we pack our columns with a homogenized blend of site soils and eliminate voids. The effects of soil heterogeneities, gravity forces, and field time-scales can best be tested with the three-well treatability test. The laboratory treatability test for leachable hydrocarbons was be operated with a maximum pressure cycle of 10 psig, a value that simulates the expected long-term operating pressure in the field.

Comment 13: Section 7.3, Steam Injection Procedure, Page 11. The quantitative objectives of the bench scale treatability study are not stated clearly. The percent contaminant removal expected should be stated, and the anticipated residual soil contamination should be identified.

Response 13: The purpose of the laboratory treatability studies is to evaluate the capability of SEE to remove hydrocarbons for the Site 13 soils through steam distillation. As described in Appendices B and C to the final Work Plan, the laboratory treatability studies indicate that SEE is not expected to produce an a appreciable mass of the total hydrocarbons, but that the more volatile hydrocarbons may be removed through steam distillation.

Comment 14: Section 8.0, Pilot Scale SEE Design. The dewatering is planned to lower the water table to at least 10 feet below ground surface. This represents approximately 6 feet of the aquifer. This dewatering is said to be necessary during the 3 well treatability study test and the scaled up 15 well treatability study test. Dewatering the aquifer by 6 feet over a 30 day period, if possible, would require significant planning. Such planning is not provided in this Work Plan. The following questions should be answered before proceeding:

- How will the discharged water be managed?
- Is there knowledge that it is possible to dewater the aquifer by 6 feet over an extended period of time.

 Is there knowledge that by pumping the aquifer for that period of time, other contaminant plumes will not be pulled toward the test site?

Response 14: Dewatering of the site and the potential for affecting other contaminant plumes is addressed in response 5.

Comment 15: Same Section, Page 17. The enhanced condensation surface containment design includes application of water via a sprinkler system. There is no drawing depicting this system, and it is unclear where the sprinkler water discharges. How is this water managed? What are the expected volumes of runoff? These questions should be answered in the text and with drawings depicting details.

Response 15: Figure 7-10 of the final Work Plan depicts the actively cooled surface containment system and placement of sprinklers. The system is described in Section 7.5 of the final Work Plan. Based on heat transfer calculations, it is expected that approximately 50 gallons per minute of cooling water will be required as described in Section 7.5. The water runoff from the surface covering will not contact contaminants and should be clean and will be recycled for re-use as cooling water.

Comment 16: The second paragraph discusses the effluent treatment system which is designed to treat both the effluent vapor mixture and the liquid water pumped from the extraction wells. The "liquid water" waste stream needs explanation. Is this the water being pumped during aquifer dewatering? What are expected volumes?

Response 16: The "liquid water" is the water pumped from the injection/extraction wells. Sections 7.3 and 7.6 of the final Work Plan address expected flow rates.

Comment 17: The third paragraph describes the "effluent liquid treatment system that recovers and treats liquids injection/extraction wells and surface separation vessels". It is not clear between the second paragraph and the third paragraph which waste stream is being discussed. In addition, the text mentions "discharge limits", but does not specify what entity or agency has issued these discharge limits, nor where water will be discharged. The text also fails to identify which sewer system is intended for use, and who would be responsible for permission to discharge into the sewer.

Response 17: The second paragraph on Page 17 of the draft work plan started with a general statement on the effluent system for both the vapor and the liquid streams. The rest of this paragraph was then given to discussion of the effluent vapor treatment. Section 7.5 of the final Work Plan presents a revised description of the effluent treatment system.

The treated water will be disposed of to the existing NAS Alameda waste water collection system. A discharge permit will be obtained from the East Bay Municipal Utility District and the effluent quality will meet the discharge requirements established in the permit. Section 7.5 of the final Work Plan includes this information and the point of contact for the discharge.

Comment 18: Section 9.1.1, Three-Well Treatability Study, Page 18 The site will be surveyed on a 20-foot grid. It is unclear why surveying on this scale is necessary for grading. A survey of the site has been conducted

already, and all wells and borings are already surveyed. If UC Berkeley would benefit from this survey data, PRC will provide it upon request.

Response 18: The site has already been surveyed using a grid spacing larger than 20 feet. The 20-foot grid requirement has been deleted from the final Work Plan.

Comment 19: The text does not specify the size of containment area needed. However, Figure 9-2 shows an area approximately 70 feet square. If the design is not known, as indicated in the text, then is Figure 9-2 incorrect?

Response 19: The steam zone will evolve from each well in a hemispherical shape beginning at the bottom of the injection well and extending to the surface. For design purposes, we will size the surface containment system to extend a minimum distance from the injection/extraction well equal to the depth of the well. The size and extent of the steam zone will be routinely monitored to keep the steam zone within the containment system. Control of its shape and size is relatively straight-forward through control of steam injection rates and intervals, and vapor and groundwater pumping rates. The size of the steam zone will be monitored as described in Section 7.4 of the final Work Plan to keep the steam zone within the surface containment system. The dimensions of the surface containment systems is described in Section 7.5.

Comment 20: The fourth paragraph itemizes the equipment needs, such as oil-water separators, liquid storage tanks, carbon canisters, and vapor condensers, but does not indicate the sizes needed. This is an indication that the anticipated volume of waste to be generated is not known, but it should be. Proper waste management is critical to the regulatory agencies

Response 20: The expected size of each piece of treatment equipment is specified in Table 7-1 of the final work plan. However, the sizes were estimated using an assumed hydraulic conductivity for the water bearing materials. As specified in Section 5 of the Sampling and Analysis Plan for the Three-Well Treatability Test, Appendix F to the final Work Plan, aquifer testing will be conducted to determine the transmissivity and storativity of the water bearing materials. The values obtained by aquifer testing will be used to review the sizing of the treatability equipment and the sizing will be adjusted accordingly prior to procurement and installation of the treatment equipment.

Comment 21: The ninth paragraph, on page 19, discusses the aquifer pumping test. However, the text does not mention providing an aquifer pumping test plan. The aquifer pumping test plan should be provided before beginning the treatability study, and should include information about the type of test, the location of observation wells, the expected radius of influence, the length of the test, the volume of water expected to be generated, and the test results analysis methodology

Response 21: The aquifer testing plan is included in Section 5 of the Sampling and Analysis Plan for the Three-Well Treatability Test, Appendix F to the final Work Plan.

Comment 22: The eleventh paragraph mentions the installation of electrodes using a cone penetrometer tool. Will the electrodes be left in the ground upon completion of the test?

Response 22: The electrodes will remain in the ground until the treatability study is discontinued, at that time they will be removed.

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Comment 23: Section 9.1.2, Pilot Scale Test, Page 21. The fourth paragraph discussed the eventual selection of the best of two surface containment systems. However, nowhere in the Work Plan, is the selection criteria discussed. How will it be determined that one system is better than the other?

Response 23: As presented in Section 7.5 of the final Work Plan, the selection will be made on both price and performance. The installation price of the active and passive systems will be comparable. The operation of the active system will be more expensive because it will require cooling from the sprinkler system and handling of the runoff. The performance of the systems will be evaluated based on the effectiveness of the containment and recovery of vapors without clogging.

Comment 24: The tenth paragraph mentions that the pilot scale test system will be operated for a period of 180 days, or "until recovery rates drop to sustained values less than 25 gallons of oil per day". How was this volume derived, and why is this a criteria for ending the test? This information needs further clarification.

Response 24: The final Work Plan addresses the three-well treatability test only. Performance criteria for the 15-well pilot-scale test will be addressed in the work plan for that test, if the decision is made to proceed beyond the three-well treatability test.

Comment 25: Section 9.3, Site Sampling and Analysis Plan, Page 22. The first bullet item indicates that further characterization is needed to define the extent of chemicals and refinery waste. However, the statement on page 18 indicated that further characterization was needed to provide "oil concentration quantification", and that the delineation was adequate. What is the purpose of additional sampling and analysis?

Response 25: Page 18 of the draft Work Plan stated that the <u>maximum</u> extent of the waste oil distribution was delineated. However, additional characterization of the hydrocarbon concentrations in the planned treatment zone is necessary to identify the vertical extent and concentration of hydrocarbons in the planned treatment area. As described in Section 7 of the final Work Plan, this information will be used to select the final locations and design of the injection/extraction wells. The data will also be used to establish baseline chemical conditions prior to injection of steam.

Comment 26: Section 9.3.2, Injection/Extraction Well Installation, Page 24. The text indicates that the location of the additional twelve wells for the scaled up pilot test would be selected "on the basis of the results of the treatability test". Specifically, what criteria will be used to determine those locations? Radius of influence observed during the 3 well test? The subsurface stratigraphy? This is one of the objectives that should be more clearly defined in the Work Plan.

Response 26: The final Work Plan has been revised to include only the three-well treatability test. Spacing of wells for the 15-well pilot-scale test will be addressed in the work plan prepared for that phase if the decision is made to proceed beyond the three-well treatability test.

Comment 27: Section 9.3.3 Hydraulic Testing. See comment on Section 8.0.

Response 27: See Response 21.

Comment 28: Section 9.3.6 Operational Monitoring. A figure should be provided to show the entire system, and the monitoring points on the system. The number of ports or effluent locations should be specified.

Response 28: Figure 7-12 of the final Work Plan shows the monitoring points within the effluent treatment system. The measurements to be obtained from each point are summarized in Table 7-3.

Comment 29: Under Influent and Effluent Sampling, the "base water treatment plant" should be identified by name, and a point of contact should be provided.

Response 29: Treated water will be discharged to the NAS Alameda wastewater collection system under a permit from the East Bay Municipal Utility District. The point of contact at EBMUD is Robert Newman and the point of contact at NAS Alameda is Randy Cate. Section 7.6 of the final Work Plan and Section 8.1 of the Sampling and Analysis for the Three-Well Treatability Test, Appendix F to the final Work Plan, have been revised to include this information.

Comment 30: Quality Assurance/Quality Control Procedures, Page 31. The text of the first paragraph states "Our goal is to maintain $\pm 10\%$ accuracy on all mass and energy balances, which will require calibration diligence, backup of critical data acquisition systems, and extensive subsurface temperature measurements." It is unclear how the initial content of oil waste in the soil is calculated, since this information is not provided. In addition, the expected volumes and concentration of the groundwater constituents is not provided, and this is part of the mass balance. If the mass balance referred to is only related to the constituents being input then this needs to be clearly stated. Otherwise, the calculated masses of waste initially present in both media should be provided. If the mass balance includes liquid and waste as output, then a goal of $\pm 10\%$ accuracy for a mass balance is an ambitious goal.

Response 30: We agree that a goal of ±10% is a very ambitious, impractical, goal for hydrocarbon mass balances in the field. Our revised goals are to 1) detect a halving in hydrocarbon concentrations, either total or leachable, from soil, 2) maintain a ±50% precision on all initial and final measurements of hydrocarbon mass in soil, 3) maintain a ±20% precision on measurements of extracted hydrocarbon mass, and 4) maintain a ±10% accuracy on all energy calculations. We will maintain ±50% numerical accuracy with calculations involving mass and energy balances. This is addressed in Section 11 of the Sampling and Analysis Plan for the Three-Well Treatability Test, Appendix F to the final Work Plan. The accuracy of measurements of concentrations of polycyclic aromatic hydrocarbons (PAHs) in soil is also limited by analytical difficulties inherent in detecting PAHs in a heavy waste oil. The mass balance will not include the initial mass of hydrocarbons in the soil, but will be performed to quantify the volume of hydrocarbons recovered during the three-well treatability test.

Comment 31: The scales on all figures need to be corrected or removed. They are not consistent from figure to figure, and they are not consistent with actual site dimensions.

Response 31: Done.

Comment 32: The legends should be more accurate, and indicate that the contamination depicted is approximate in extent, and that the well locations are approximate only (since that is what the text of the Work Plan indicates).

Response 32: Done.

Comment 33: The injection/extraction well diagram does not show a pump in the well for liquid removal. It is not clear from text or figure 8.3, how liquid is pumped from the well.

Response 33: The location of the pump has been added to Figure 7-4 of the final Work Plan and a diagram of the planned well pump is included as Figure 7-5 of the final Work Plan. The pump may be raised and lowered in the well.

Comment 34: There should be a "plan view" figure showing the surface covering design. It is unclear whether this sits over the wells, and also it is unclear exactly how liquid is collected and directed toward the effluent treatment system. Only the passive surface cover design is provided; the active cover design figure should also be provided.

Response 34: The layout of the actively cooled and passive surface containment systems is shown on Figure 7-9 of the final Work Plan. Details of the collection systems are presented in Section 7.5 of the final Work Plan.

Comment 35: Table 9.3 shows a summary of samples to be collected. The title of the table should be changed accordingly. Also, it is unclear from the table whether adequate trip blanks are being collected. There will be a trip blank in every cooler. It is assumed that the samples will be stored and shipped together in groups, but there is no schedule table to show this. The table should be designed so that when the field work is ongoing, there is a clear guide for collecting and sending samples to the laboratory. This table does not meet that need.

For each step of the test, and for each day, there should be a clear guide for the types and numbers of quality control samples being collected.

Response 35: Tables 1-2, 2-1, 2-2, 8-1, and 9-1 of the Sampling and Analysis Plan for the Three-Well Treatability Test, Appendix F of the final Work Plan detail the field and QA/QC samples to be collected during each stage of the three-well treatability test.

RESPONSE TO COMMENTS ON JUNE 30, 1995 PILOT SCALE TREATABILITY STUDY WORK PLAN APPENDIX A: LABORATORY TREATABILITY TEST RESULTS PRC ENVIRONMENTAL MANAGEMENT, INC. 20 March, 1996

Comment 1: Introduction, Page 1. The goal of the laboratory treatability test, as stated in the second paragraph of the introduction, was "To better define the characteristics of the effluent liquids and residual waste oil . . . "However, in the first paragraph, the questions posed, and the statements made indicate that the goals of the laboratory treatability test might have included (1) finding whether SEE technology would be effective for Site 13 soil, (2) whether SEE technology would be a cost-effective means of complete hydrocarbon removal, and (3) whether the "acidic" conditions at the site and metal stability may be positively affected by the steaming process." Since the decision to proceed on to the three well pilot test is made by the Navy and agencies, the document should provide them with a clear statement of goals. Also, the proposed criteria for deciding whether the goals are met should be provided.

Response 1: The goal of the laboratory treatability test for total hydrocarbons was as stated. The data obtained in meeting that goal, presented in Appendix B of the final Work Plan, raised additional questions which were addressed by the laboratory treatability test leachable hydrocarbons described in Appendix C of the final Work Plan. In response to this comment, the goals and objectives of the laboratory treatability testing are clarified in Section 1 of the final Work Plan. The performance criteria for the three-well treatability test are included in Section 7.8 of the final Work Plan.

Comment 2: As it is stated in the introduction, it is unclear whether the physical/technical effectiveness of the SEE technology is the limitation to proceeding to pilot scale, or cost effectiveness is the limitation. Later in the text, it appears that both are limitations.

Response 2: The results of the laboratory treatability test for total hydrocarbons showed that the most volatile components of the waste oil in the site are removed by steam distillation in a cost-effective fashion. However, it may not be cost effective or technically viable to remove the heavier hydrocarbon compounds. If significant reduction in future site risk may be obtained by cost effective removal of the volatile components by the application of SEE, then field-scale testing of SEE should proceed to the three-well treatability test. This test will also provide an assessment of the ability of SEE to upwardly mobilize separate phase hydrocarbons. Because of this, we recommend proceeding to the three-well treatability test. Criteria for proceeding to the 15-well pilot-scale test are included in Section 7.8 of the final Work Plan.

Comment 3: One Dimensional Experimental Apparatus, Page 1. It is unclear how the laboratory setting, in which the heat loss is controlled, is comparable to field conditions. It is assumed that the control of heat loss in the field will be minimal or impossible. If laboratory test results are to be applied to the decision to conduct a field scale test, the relationship between laboratory and field implementation should be discussed.

Response 3: As stated in the report on the laboratory treatability test for total hydrocarbons (Appendix B of the final Work Plan) and in the final Work Plan, the

laboratory tests focus on steam distillation of the waste oil in the soil. To evaluate this mechanism, adiabatic control during the laboratory treatability study is necessary. The effects of pressure and temperature in facilitating removal of hydrocarbon constituents from soils is expected to be similar in the soil column and in field soils Under field conditions, heat losses occur at the periphery of the steam zone. Control of the heat loss at the periphery of the steam zone is maintained by balancing steam injection rates against heat loss rates as indicated from subsurface temperature measurements and enthalpy flux balances. Within the steam zone, the steam distillation process is well represented by the laboratory conditions. There, the temperatures are spatially uniform and energy fluxes are dominated by the flowing steam, as in the laboratory treatability experiment. Additional descriptions of the relationship between laboratory and field implementation are given in Appendix E of the final Work Plan.

Comment 4: Soil Sample Preparation, Page 2 and 3. It is unclear whether the bench scale study will simulate field conditions, because the text indicates that the sample will be compacted to minimize voids; further, the text states that "voids are undesirable since they compromise the homogeneity of the one-dimensional sand pack and could lead to uneven steam flow. "Since it is assumed that field conditions will be different, and soil voids will cause uneven steam flow, the text should describe how laboratory and field conditions compare, and how the information gathered during this laboratory study will be used in making the decision to try this technology in a field setting.

Response 4: As noted in response 3, the laboratory treatability test for total hydrocarbons focused on steam distillation of the waste oil, not flow of steam through the subsurface. Response 2 also addresses how the decision to scale-up to the field tests is made

Comment 5: Steam Injection Procedure, Page 5, The text describes how a valve at the bottom of the soil sample holder was closed during a period of steam injection, and then opened while the steam injection was steadily maintained; this procedure was repeated for an unseated number of times. It is unclear how this pressure/temperature cycling simulates field conditions. In the field study, the system presumably, will not be a closed system, and this cycling may not be possible. The text should discuss how this technique relates to the scaled up study in the field.

Response 5: Pressure cycling after the contaminated regions reach steam temperatures has been shown in the LLNL Gas Pad Demonstration and the NAS Lemoore Pilot Demonstration, to be possible in the field. Furthermore, experimental, theoretical, and computational studies conducted at UCB have shown the enhancement of mass transfer rates during steam distillation of compounds from heterogeneous soils brought about through pressure cycling of a steam zone. The applicability of pressure cycling to field conditions is addressed in Section 2.1 of the Sampling and Analysis Plan for Laboratory Treatability Studies, Appendix E to the final Work Plan.

Comment 6: Results: Post Steam Soil Analytical Results, Page 8, 9, and 11, The test results on Table A.3. show variable motor oil concentrations in post steam soil samples. The table also shows that the diesel concentrations were decreased in the sample tube. Because the motor oil concentrations were variable, but did not decrease, further discussion should be provided for the motor oil results. For example, the text should discuss the range of error associated with the analysis for motor oil. PRC

chemists believe there could be up to 50 percent error associated with the results shown on the table. This may explain why the samples taken from several of the intervals contained concentrations of motor oil higher than the original sample. The original sample, "SO," was found to contain 32,000 milligrams per kilogram (mg/kg) of hydrocarbons which included 12,000 mg/kg diesel, and 20,000 mg/kg motor oil. (However, the text on page 12 states that the original concentration was 45,000 mg/kg.) The post steam sample concentrations varied from 12,000 mg/kg to 36,000 mg/kg motor oil. The sample with the lowest concentrations was taken from the midpoint of the sample tube, and the sample with the highest concentration was taken from the location nearest the steam inlet. The results are confusing unless a discussion of analytical error is provided.

Response 6: It is not possible to use one standard to quantify the concentration of hydrocarbons in soil or effluent samples with EPA 8015 when the composition changes as dramatically as it does during steam distillation. Additionally, the oily material is likely not gasoline, kerosene, diesel, motor oil or any other available standard, so the use of response factors for these standards to absolutely quantify the oily material fractions likely has some bias. Given the lack of toxicological data and apparent "waste" nature of the material, in addition to weathering over some 90 years, developing an accurate response factor for this material is of questionable value. The data are better regarded as useful for a relative comparison of hydrocarbon fraction removal by SEE. Appropriate analytical procedures and discussions of analytical results are specified in Appendices B, C, and E of the final Work Plan.

We agree that a 50% error may exist in the analytical results for hydrocarbons as presented in Table A-3 included in the draft work plan due to changing composition of the effluent and thus accurate assessments of the fraction of hydrocarbon mass removed is not possible. Regardless, the evaluations and conclusions presented are not sensitive to such error because the goal of the experiment was to better define the characteristics, not the composition, of the effluent liquids and residual waste oil.

Comment 7: On page 9 of the text, the last sentence is unclear. It states "The numbers reported, while self-consistent, are not fully representative of the effluent concentrations due to the limited range of diesel and motor oil standards." It is unclear whether this sentence is meant to imply that the reported concentrations are incorrect. The comparison to diesel and motor oil standards may not have been appropriate; maybe a waste oil standard would have matched the chromatogram better.

Response 7: The reported concentrations are not "incorrect", but there is unknown bias because of the response factors issue, and likely some variability in extraction and analytical performance because of the high molecular weight nature of the oily material. The waste oil present in the subsurface at Site 13 is a mixture of hydrocarbons and the best way to get an estimate of the total concentration of the hydrocarbons present is to perform an analysis for total petroleum hydrocarbons. However, the total amount of hydrocarbons removed is not the only important factor for the laboratory treatability test. By analyzing for petroleum hydrocarbons as diesel and motor oil, we are able to identify the types of hydrocarbon fractions that are removed. These analyses identify only hydrocarbons within a certain range and will not necessarily identify all of the hydrocarbons present. The numbers obtained are not necessarily representative of the absolute quantity of total hydrocarbons present and this is why we stated that they are not fully representative of the effluent concentrations. Appendix C of the final Work Plan addresses this issue. A waste oil standard would not have matched the chromatograms better since there was likely so

much variation in composition over the site.

Comment 8: On page 11, under Cumulative Mass Removed, the last sentence states "It is of note that the removal rates during the later parts of the experiment were comparable to those that might be expected during isothermal groundwater pumping." Please explain the term "isothermal pumping."

Response 8: Isothermal groundwater pumping refers to standard groundwater pumping at ambient temperatures. The rate of contaminant removal by isothermal groundwater pumping is mentioned to provide perspective. Recovery rates at the beginning of the laboratory treatability test for total hydrocarbons were orders of magnitude higher than could be obtained by isothermal groundwater pumping. Comparison of latter stage distillation rates with isothermal groundwater pumping was made to highlight the low volatility of the contaminants remaining in the soil.

Comment 9: Energy Cost Analysis, Page 12, The text in the middle of the first paragraph states "The fraction of the initial hydrocarbon mass that was removed during the steaming process was calculated from the mass of hydrocarbon remaining in the soils after steaming plus the total mass of hydrocarbons removed during the steaming process since the original concentration of hydrocarbons in the unsteamed soil is considered less reliable than the post steaming concentrations or cumulative hydrocarbon mass removed." Please explain more clearly how the fraction removed was calculated. It is not clear what is meant by "the total mass of hydrocarbons removed." Does this mean the hydrocarbon found in the effluent? Please explain why the original concentration of hydrocarbons in the unsteamed soil is less reliable than the post-steaming concentrations. Please explain what is meant by "cumulative hydrocarbon mass removed."

Response 9: Cumulative hydrocarbon mass removed is the sum of the mass of the hydrocarbon found in all effluent samples. The term cumulative hydrocarbon mass removed in all effluents is synonymous with total hydrocarbon mass removed. The fraction removed was calculated by dividing the total hydrocarbon mass removed by the sum of the total hydrocarbon mass removed and the total mass of hydrocarbon residual in soil; this value may be an overestimate of the hydrocarbon mass removed if some of the mass in soil is not able to be analyzed (low volatility, retained in the instrument injector.) The original hydrocarbon concentrations in the unsteamed soil are less reliable because the hydrocarbon range in unsteamed soil is broad. The light ends are removed by steam distillation, leaving a narrower range of hydrocarbons that is more easily quantified. Because the effluent sample chromatograms of samples of highest hydrocarbon mass were similar to diesel and motor oil standards, the reported concentrations were considered more reliable.

Comment 10: Further, in this paragraph, the text indicates that the initial mass of hydrocarbons in the unsteamed soil was estimated to be 45,000 mg/kg. This is the concentration used to calculate the 25 percent removed value. However, the discrepancies between Table A.3. and this paragraph should be explained. Also, this paragraph seems to discredit the values shown on Table A.3. Please clarify the test results.

Response 10: Additional analysis of the original soil was conducted after submission of the report on the laboratory treatability test for total hydrocarbons and the data is more consistent with the effluent data. The data have been included in Appendix B of the final Work Plan. However, the discrepancies do not disappear. The concerns expressed by the

reviewer are those documented in the report and addressed in the description of the laboratory treatability study for leachable hydrocarbons, Appendix C of the final Work Plan

Comment 11: On page 13, the second paragraph includes the statements "Second, mobilization and capture of the liquid oil will be much more effective in removing oil mass than steam distillation. Third, if pH reduction is considered to be a priority function of the in situ cleanup of this site, then steam injection of relatively short duration may be valuable." Please explain what is meant by "mobilization and capture." If this is a different technology than the SEE technology, a description should be provided. If this is a recommendation for another technology that should be made clear. Also, should the second sentence read "...pH increase ..." instead of "...pH reduction..."?

Response 11: Yes, the text should read pH increase. The change has been made in the Appendix B of the Final Work Plan. As described in the Section 7.7.2 of the final Work Plan, the upward mobilization and capture of liquid waste oil due to heating is part of the SEE process. The fluids are then captured by pumping from the injection/extraction well and pumped to the treatment system for separation from the effluent water and subsequently recycled.

Comment 12: Conclusions, Page 13, The text reads "SEE does have the ability to restore the soil water to neutral pH from an initial effluent sample pH of 2. 1, and reduce[d] the aqueous phase hydrocarbon concentration by a factor of 5.6 at a point half way through the treatability test." Please explain how the factor of 5.6 was calculated. Also, please explain in detail, how the initial effluent sample relates to soil pore water. From the test description, it appears that effluent is the result of steam dissolved hydrocarbons in water, and that the pH of this would not relate to the pH of the soil pore water. It is not necessarily true that the in situ soil pore water has low pH values like that of the effluent. It seems that the measured pH of 2.1 in the effluent could be indicative of whatever was dissolved with the steam, and not necessarily of the initial soil pore water pH.

Response 12: The pH of the first effluent sample may have been low because of interactions between the steam, soil, and unknown constituents in soil. Experience in other SEE treatability studies has shown that the initial steam front displaces soil pore water and that the initial quality of the effluent stream is representative of initial pore water quality. Again, the goal of the first laboratory treatability test was "[t]o better define the characteristics of the effluent liquids and residual waste oil . . . " and to identify the hydrocarbons that are removed through steam distillation. Procedures for conducting a focused treatability test to evaluate the leachability of the hydrocarbons and the effect on pH of the soil water were developed and are presented in the Sampling and Analysis Plan for Laboratory Treatability Studies, Appendix E of the final Work Plan. The results of the laboratory treatability study for leachable hydrocarbons, which addressed the pH of the effluent, are described in Appendix C of the final Work Plan.

Current field data on soil and groundwater pH indicates variable conditions. Previous data supplied to UCB indicates that most of the Site 13 soils have a pH greater than 7 but that soil removed from the southern portion of the site had a lower pH. The pH of the initial fluid that was removed from the initial lab treatability steam injection test was found to be 2.1, but it is unclear whether that value represents water in intimate contact with disturbed

soil or some contributing effect of steam/soil interaction. The mitigation of the acidity in soil is reasonably due to the effect of steam treatment displacing the acid constituents in the first volume of pore water and the steam also breaking up and extracting the acid constituents from the oily material mass, which is a parallel process to removal of the low molecular weight hydrocarbon components.

The factor of 5.6 was calculated by dividing the initial concentration of hydrocarbons (diesel and motor oil fractions) in the effluent by the concentration of hydrocarbons in the effluent at a point half way through the treatability test.

RESPONSE TO COMMENTS ON JUNE 30, 1995 PILOT SCALE TREATABILITY STUDY WORK PLAN DEPARTMENT OF TOXIC SUBSTANCES CONTROL 20 March 1996

Comment 1: The results of the appendix A: Laboratory Treatability Test Analytical Results (Lab Test) of the Pilot-Scale Treatability Workplan (Workplan) clearly indicate that the ability of steam enhanced extraction (SEE) to economically remove a significant mass of hydrocarbons from Site 13 soils is questionable. The Workplan indicated the results of this labscale treatability test would determine if it would be worthwhile to implement a SEE pilot-scale test at Site 13. Based on the results of the lab-scale test, we recommend the termination of efforts to implement a pilot-scale SEE treatability test at Site 13 for the purpose of mass removal of subsurface hydrocarbons.

Response 1: The results of the laboratory treatability test for total hydrocarbons do show that a large fraction of the hydrocarbon mass is essentially non-volatile, and presumably not mobile to the SEE process. The suggestion to terminate of efforts to implement the three-well pilot treatability test at Site 13 is reasonable if the mass removal of subsurface hydrocarbons is the sole decision criteria. However, the more volatile and therefore mobile fractions were removed from the soils through the application of steam during both the laboratory treatability tests for total and leachable hydrocarbons. This result indicates that the more mobile fractions can be removed during field implementation through steam distillation. The results of the laboratory treatability tests are described in Appendices B and C to the final Work Plan.

Another SEE mechanism is the upward mobilization of separate phase hydrocarbons, where the heat induced reduction of the viscosity of the hydrocarbon mass enables the light nonaqueous phase liquid (LNAPL) to flow by buoyant forces to the water table where it can be recovered. The best scale for testing the effect of steam on this mechanism is under field conditions; the soil is undisturbed, the temperature field would be realistic, and the upward buoyancy forces related to the vertical dimension of the contaminated zone can be properly scaled.

Comment 2: The recommendations section of the Lab Test indicates that the removal of the most volatile fraction of the hydrocarbon mass, and the restoration of the site to neutral pH may be possible at modest cost and that these changes may have sufficient effect on contaminant mobility and future biodegradation rates to allow the cleanup objective to be met without further treatment of subsurface soils at Site 13. The Lab Test indicates that an additional short duration lab-scale treatability test would be needed to assess these possibilities. We recommend the implementation of lab-scale testing to evaluate the issues noted above. In addition to the tests recommended in the Lab Test we feel that additional information is necessary in order to make a decision on implementation of a pilot-scale test with the objectives of pH restoration and volatile removal. We recommend:

a. A determination of the necessity of de-watering at Site 13 for the purpose of pH restoration and volatile removal should be made. If dewatering is mandatory for the successful implementation of a pilot-scale treatability test with these objectives, then the feasibility of de-watering

Site 13 must be determined. We recommend an analysis of groundwater pumping at Site 13 to determine if de-watering to the levels described in the Workplan is feasible.

Response 2: As described in Section 7.3 of the final work plan, dewatering will be accomplished by pumping during the initial stage of the three-well treatability test. Based on an assumed hydraulic conductivity for the water bearing materials, it is expected that a pumping rate of approximately 1 gallon per minute will be required to lower the water table by one foot at each injection/extraction well. However, the amount of water table depression that will be required to enhance recovery of free phase hydrocarbons is uncertain and will have to be adjusted in the field. Aquifer testing, described in Section 5 of the Sampling and Analysis Plan for the Three-Well Treatability Test (Appendix F to the final Work Plan) will be conducted to provide better characterization of the water bearing materials prior to the installation of the effluent treatment system and initiation of the three-well treatability test. The transmissivity and storativity measured with the pumping tests performed will be used to reevaluate the ability to dewater the treatment area by pumping.

During subsequent stages of the three-well treatability test, dewatering will be accomplished primarily through displacement by steam. Experience with steam injection, both field and laboratory, has shown that water is displaced by the advancement of the steam zone and thus de-watering can be achieved locally in the steam zone. The steam injection pressure must be significantly higher than the local hydrostatic pressure before steam can be injected below the water table, and it is therefore the steam pressure gradient that controls the displacement of the other mobile fluids. The volume of water pumped from the subsurface to achieve de-watering is thus of the order of a pore volume. The treatability system will also have the capabilities of pumping from the injection/extraction wells to lower the water table. This is also described in Section 7.3 of the final Work Plan.

To evaluate the response of the subsurface fluids to the injection of steam, a numerical simulation of steam injection using the design parameters has been run to obtain the water saturation profile for different times using M2NOTS-TOUGH2. That code is a fully validated multiphase multicomponent simulator for porous media flow developed at the Lawrence Berkeley National Laboratory and UCB. The results of the simulation are described in Appendix G of the final Work Plan.

Comment 3: An analysis of groundwater pH at varying depths and locations at Site 13 should be performed to determine if pH levels documented in the Lab Test are localized or are consistently low throughout the site. With hope, sufficient characterization data on groundwater pH already exists, but if not we recommend the implementation of field testing to develop this profile.

Response 3: We understand this concern. Current field data on soil and groundwater pH is incomplete for describing the pH conditions. Previous data supplied to UCB indicates that most of Site 13 soils have pH values greater than 7 but that soil removed from the southern portion of the site had a low pH. The pH of the initial fluid that was removed from the first lab treatability steam injection test was found to be 2.1, but it is unclear whether that value represents pore water in intimate contact with disturbed soil or had some contribution due the effect of steam contact with soil. As described in Section 1 of the Sampling and Analysis Plan for the Three-Well Treatability Test (Appendix F of the final Work Plan), soil samples collected following cone penetrometer testing will be analyzed for pH to evaluate the soil pH in the treatment area prior to the installation of the wells and treatment system for the three-well treatability test.

Comment 4: Further contaminant characterization is required in the form of: 1) Testing to determine the density of the contaminant in the untreated form of fractions that may be created in the application of steam to subsurface contamination. It is presently not clear if DNAPL fractions may be created by the application of steam and subsequently mobilized to allow vertical migration. 2) More completely define the waste with respect to its hydrocarbon range and concentration. Presently, there are many references to different concentrations and reference standards throughout the text of the Workplan. It is understandable that with a contaminant that is composed of multiple compounds of varying complexity that it is difficult to be consistent in this area; however, any further decision making should be based on a complete representation of the contamination present. It may be necessary to use a method such as gravimetric analysis or EPA 9060 which reflects total hydrocarbon content.

Response 4: Based on observations of effluent during the laboratory treatability test for total hydrocarbons, the separate phase hydrocarbon that was removed from the contaminated soils was a NAPL that had an apparent density less than that of water; the hydrocarbons floated to the top of a beaker of water when heated. Due to the small volume of free phase hydrocarbons recovered in this experiment, no testing was done on this fluid to determine the density. In addition, the density of these free phase hydrocarbons produced by the application of steam would not have been representative of the oil initially in the soil because the produced water plus NAPL liquid showed a different chromatographic signature than that of the unsteamed soil when laboratory analyzed.

The point that the density of the waste oil currently in the soil at Site 13 may be greater than that of water or that partial steam distillation may leave oil behind that is denser than water is valid and further experimentation may be necessary to show that downward movement of the oil is not a problem. It is not likely that the concentrations of denser than water residuals would be high enough to allow free phase mobility, or that the viscosities would be low enough to provide significant downward movement rates, particularly outside the steam zone where temperatures would be much lower. Post demonstration soil sampling to demonstrate the quality of soil remaining in the hydrocarbon bearing zone as well as above and below this zone is described in Section 9 of the Sampling and Analysis Plan for the Three-Well Treatability Study, Appendix F of the final Work Plan.

Accurate hydrocarbon concentration quantification is difficult, but self-consistent data are obtainable using EPA 8015 (m) to identify specific hydrocarbon ranges because the relative changes in hydrocarbon composition can be compared. Appendices C and E of the final Work Plan describe the methods employed to evaluate soil and effluent hydrocarbon concentrations. The analyses planned for the three-well treatability test are described in the Sampling and Analysis Plan for the Three-Well Treatability Test, Appendix F of the final Work Plan. The need for other analytical methods to meet the data quality objectives for the three-well treatability test has not been identified.

Gravimetric methods of measuring total petroleum hydrocarbons are inappropriate for two reasons: 1) gravimetric methods would apply to soil only and would be difficult to compare with other methods used to estimate the mass of hydrocarbons in water, and 2) gravimetric methods for soil are relatively insensitive and would pick up only changes in hydrocarbon concentrations greater than 5,000 to 10,000 ppm. depending on the matrix.

EPA Method 9060, which is based on the measurement of CO₂ produced when all carbon compounds present are combusted, is also inappropriate for soil. According to Mr. John Goyette, a lab manager for Curtis & Thompkins Analytical Laboratories in Berkeley,

California, recoveries of chemicals added to soil matrices and analyzed by this method are poor.

Comment 5: Using the transport pathways listed in Section 5. PROBABLE TRANSPORT PATHWAYS of the Workplan, further evaluate the potential risk at Site 13 based on the type of removal rates achieved in lab tests.

We feel the accumulation of the above data, in conjunction with the results of the additional lab tests proposed, could provide essential information necessary to fully evaluate the decision to implement a pilot-scale treatability test of SEE at Site 13 for the purposes of evaluation pH restoration and volatile removal.

Response 5: A quantitative risk reduction analysis will be addressed in either the Engineering Evaluation/Cost Analysis or the Feasibility Study performed for Site 13 by the RI/FS contractor; it is beyond the scope of this treatability study. However, the results of laboratory testing indicate that the more volatile components of the hydrocarbons are removed by the application of steam and this should result in a reduction of risk.

Comment 6: The Workplan is very well done and contains all the necessary components that describe the steps necessary to implement and evaluate the application of SEE at Site 13 on a pilot-scale basis. The Workplan indicates that the implementation of the pilot-scale treatability test would be dependent on the results of a lab-scale treatability test. Both of these tests are grouped under deliverable 003. We recommend the separation of the pilot and lab-scale tests as distinct deliverables for the purpose of decision making. The appearance now is that if the lab tests are negative and indicate that pilot-scale tests are not appropriate, the Navy would still implement the pilot-scale test.

Response 6: To facilitate implementation of the pilot-scale treatability study, all three phases were described in the draft Work Plan. The final Work Plan includes the results of the laboratory tests for total and leachable hydrocarbons as Appendices B and C and describes the activities that will be conducted for the three-well treatability test. Criteria for proceeding to the 15-well pilot-scale test are included in Section 7.8 of the final Work Plan. As described in Section 1.4 of the final Work Plan, a separate work plan will be prepared for the 15-well pilot-scale test if the decision is made to proceed.

Comment 7: The Lab Test indicated that pressure cycling was used in the treatability test and this process increased the contaminant concentrations in the effluent. It is not clear what purpose this process serves in the treatability study since it would be impractical to attempt to pressure cycle in a pilot-scale test in the field. If contaminant concentrations in the effluent were increased by this process then this should be reflected in the results expected in a pilot-scale test.

Response 7: Pressure cycling after the contaminated regions reach steam temperatures has been shown in the LLNL Gas Pad Demonstration and the NAS Lemoore Pilot Demonstration to be practical in the field. Furthermore, experimental, theoretical, and computational studies conducted at UCB have shown the enhancement of mass transfer rates during steam distillation of compounds from heterogeneous soils brought about through pressure cycling of a steam zone. We believe that no further experimentation is needed to prove that pressure cycling is more effective and less expensive than constant

pressure steam injection.

Comments 8: The Lab Test indicated that in the latter part of the treatability test the effluent concentrations and removal rates were comparable to those that might be expected during isothermal groundwater pumping. It may be advisable that during any further lab treatability tests a control be established that uses water without steam to attempt to define what contribution steam is having on mass removal or other test parameters.

Response 8: The rate of contaminant removal by isothermal, or ambient temperature groundwater pumping, is mentioned to provide perspective. Recovery rates at the beginning of the experiment were orders of magnitude higher than could be obtained by isothermal groundwater pumping. Comparison of latter stage distillation rates with isothermal groundwater pumping was made to highlight the low volatility of the contaminants remaining in the soil. The procedures outlined in Appendices C and E of the final Work Plan provide data on contaminant concentrations in water. When the procedures are performed, the data are sufficient to compare the difference in recovery rates by isothermal groundwater pumping or SEE.

Comments 9: Water soluble sulfanates may be a contributor to pH levels at Site 13. Any lab or pilot-scale treatability study should address the presence of these compounds and the influence they have on pH.

Response 9: Presumably the reference is to chemicals containing the sulfonic acid group. These chemicals would contribute to the low pH values observed in some samples. However, these chemicals have high water solubilities and would be expected to be mobile along with other inorganic acid-related constituents (sulfuric acid, hydrochloric acid.) Unless a specific need for speciation of the acid source can be provided (toxicity, special treatment needs, discharge permit, etc.), the characterization of the specific acid source does not seem warranted.

APPENDIX B

RESULTS OF LABORATORY TREATABILITY TEST FOR TOTAL HYDROCARBONS

PILOT-SCALE TREATABILITY WORK PLAN STEAM ENHANCED EXTRACTION SITE 13 NAVAL AIR STATION ALAMEDA ALAMEDA, CALIFORNIA

APPENDIX B RESULTS OF LABORATORY TREATABILITY TEST FOR TOTAL HYDROCARBONS

Contract Number: N62474-94-D-7430 Delivery Order No. 003

Submitted to:

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PILOT-SCALE TREATABILITY WORK PLAN STEAM ENHANCED EXTRACTION SITE 13 NAVAL AIR STATION ALAMEDA ALAMEDA, CALIFORNIA

APPENDIX B RESULTS OF LABORATORY TREATABILITY TEST FOR TOTAL HYDROCARBONS

Revision 1

UNCLASSIFIED March 20, 1996

Approved by: _	Int 5 Will	Date:	3/20/96
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APPENDIX B

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4-2	Petroleum Removed vs Effluent Mass
4-3	Petroleum Removed vs Pore Volumes Condensed
4-4	Cost of Steam vs Fraction Oil Removed

APPENDIX B

LABORATORY TREATABILITY TEST FOR TOTAL HYDROCARBONS

1. INTRODUCTION

Previous laboratory treatability tests of the applicability of Steam Enhanced Extraction (SEE) to relatively low volatility hydrocarbon mixtures such as pole tars conducted at the University of California, Berkeley in the Berkeley Environmental Restoration Center (BERC) laboratory showed effective removal (> 99%) of those liquid compounds from soils by steam distillation alone. It is not clear whether SEE would be effective in removing the waste oil from the Site 13 soils however, since the oil may be distillation column residues and consist of very low volatility components. For such low-volatility compounds, steam distillation would not be cost effective for complete removal, but may result in substantial reductions in the mass of the more volatile fractions of the oil. The potential extent of removal of the toxic components of the waste oil from Site 13 soils by SEE, and the composition of the residual hydrocarbons are of interest, however, since reductions in the concentrations of the most volatile compounds may be enough to reduce potential health risks to acceptable levels. Furthermore, unfavorable conditions at the site such as pH values significantly different than neutral and metal concentrations near action levels may be positively affected by the steaming process.

To better define the characteristics of the effluent liquids and residual waste oil, a laboratory treatability test was conducted. The apparatus, sample preparation procedures, steam injection schedule, and soil and effluent chemical analyses for the laboratory experiment are presented in this appendix. An energy cost analysis is presented to show that complete removal of all hydrocarbons from the site by steam distillation would be cost prohibitive, while volatile hydrocarbon recovery may be obtained at for energy costs in the range of \$20/yd³. Based on this initial scoping study, further laboratory treatability tests with significantly less steam throughput volumes are recommended.

2. EXPERIMENTAL PROCEDURE

2.1 ONE-DIMENSIONAL EXPERIMENTAL APPARATUS

As shown in Figure 2-1, the apparatus for the one-dimensional treatability experiment consisted of a pair of metering pumps to deliver a constant mass flow rate of distilled water, a steam generator to boil the water into steam, a stainless steel pipe to hold the contaminated soil sample, and an effluent collection jar maintained in an ice bath to minimize loss of components from the effluent to the atmosphere.

The inlet and outlet of the sample holder had end caps which could be unbolted and removed to pack and unpack the soil sample. These caps had channels cut on their inner surface in contact with the soil to help spread the injected steam across the entire inlet cross section of the sample holder and reduce the end effects of the one-dimensional experiment. In addition to these channels, three-hundred and twenty-five mesh stainless steel screens

were attached to the inner surfaces of the end caps to encourage uniform spreading of the steam over the sample holder cross section and to prevent the grains of soil in the sample from escaping the sample holder.

The stainless steel sample holder was wrapped with heater tape and insulated. During injection, this heater tape was set to a constant supply power to offset the heat loss through the insulation, maintaining a constant temperature along the length of the tube and thus producing an adiabatic environment. Thermocouples were mounted at the steam inlet tubing, the upstream end of the soil sample, the downstream end of the soil sample, and the outlet tubing. Teflon tubing was used to carry all fluids into and out of the system. The outlet tubing was long enough to allow the effluent to cool to near room temperature before it entered the effluent collection bottle. Because flow rates were low, usually one meter (3.3 feet) of tubing was a sufficient length. When the effluent flow rate was too high to condense all of the steam in the effluent tube, a condenser stage was added to the outlet tubing between the outlet of the stainless steel piping and the effluent collection jar.

The apparatus thus configured provides an adiabatic environment in which to simulate interaction of steam with contaminants. The laboratory tests focus on steam distillation of the waste oil in the soil. To clearly evaluate this mechanism, adiabatic experimentation is necessary. Under field conditions, heat losses occur at the periphery of the steam zone. Control of the heat loss at the periphery of the steam zone is maintained by balancing steam injection rates against heat loss rates as indicated from subsurface temperature measurements and enthalpy flux balances. Within the steam zone, the steam distillation process is well represented by the laboratory conditions. There the temperatures are spatially uniform and energy fluxes are dominated by the flowing steam, as in the laboratory treatability experiment.

2.2 SOIL SAMPLE PREPARATION

Soils were taken from contaminated regions of Site 13 at the location UCB-2 using a hand auger. The soil samples were taken from beneath the water table in a region of high contaminant concentration. The soil was chilled to reduce hydrocarbon vapor pressures and mixed in a clean Pyrex tray to uniformly distribute the waste oil throughout the sample. One sample was sent to an outside laboratory for analysis for total extractable hydrocarbon (TEH) concentrations in the diesel and motor oil ranges, polyaromatic hydrocarbon (PAH) concentrations, and metal concentrations.

Hydrocarbon laden soils were packed into the stainless steel sample holder by alternately adding a few centimeters of soil and compacting with a large wooden dowel to reduce void spaces in the pack. The thermocouples situated within the soil were inserted during packing. Packing continued until enough soil was in the sample holder to require slight soil compression by the end cap when it was bolted into place. This compression minimized the voids created during settling of the sand pack.

The soil was homogenized and tightly packed in the test cell. While this procedure does not reproduce exact field condition, the laboratory treatability tests are designed to provide clear, unambiguous results regarding leachability, steam distillation rates, and pH variations during SEE application to the site soil and waste oil. The homogenization and elimination of voids reduces permeability and concentration variability, thus simplifying and clarifying interpretations of laboratory tests. The effects of field-level soil heterogeneity, gravity forces, and time scales is best tested with the three-well treatability test since laboratory testing would on such a scale would be much more expensive and less representative than a field trial.

2.3 STEAM INJECTION PROCEDURE

After packing the sample holder with contaminated soil as described in the sample preparation section, the metering pumps were set to provide a constant water flow rate of 38 milliliter per hour (ml/hr). Since the contaminant concentrations removed by steam were highest during the first part of injection, sampling was more frequent in the early stages of the experiment in order to provide better resolution of initial effluent contaminant characteristics. All of the effluent coming from the sample holder was collected into sample bottles according to the regime identified in Table 2-1:

Table 2-1. Sampling Regime

	1		Time In Place	Cumul ati v e
	\vdash	Sample Time	(hours)	Time (days)
	\vdash		(nours)	
Begin		4/28/95	1.4	0.0
Sample	1	4/28/95		
Sample	2	4/28/95	1.0	0.1
Sample	3	4/28/95	1.0	0.1
Sample	4	4/28/95	1.0	0.2
Sample	5	4/28/95	1.0	0.2
Sample	6	4/28/95	2.9	0.3
Sample	7 8	4/28/95	4.0 4.0	0.5 0.7
Sample	+ -	4/29/95		***************************************
Sample	9	4/29/95	4.0	0.8
Sample	10	4/29/95	8.2	1.2
Sample	11	4/29/95	7.8	1.5
Sample	12	4/30/95	8.4	1.9
Sample	13	4/30/95	7.4	2.2
Sample	14	4/30/95	12.4 11.5	2.7 3.2
Sample	15	5/1/95		
Sample	16	5/1/95	12.5	3.7
Sample	17	5/2/95	11.8	4.2
Sample	18	5/2/95	24.0	5.2
Sample	19	5/3/95	24.0	6.2
Sample	20	5/4/95	24.0	7.2
Sample	21	5/5/95	24.0	8.2
Sample	22	5/6/95	24.0	9.2
Sample	23	5/7/95	24.0	10.2
Sample	24	5/8/95	24.0	11.2
Sample	25	5/9/95	24.0	12.2
Sample	26	5/10/95	24.0	13.2
Sample	27	5/11/95	24.9	14.2
Sample	28	5/12/95	25.4	15.3
Sample	29	5/23/95	0.3	15.3
Sample	30	5/23/95	24.6	16.3
Sample	31	5/24/95	24.9	17.4
Sample	32	5/25/95	24.0	18.4
Sample	33	5/26/95	24.4	19.4
Sample	34	5/27/95	17.3	20.1
Sample	35	5/28/95	25.5	21.2
Sample	36	5/29/95	23.7	22.1
Sample	37	5/30/95	24,2	23.2
Sample	38	5/31/95	23.9	24.1
Sample	39	6/1/95	24.9	25.2
Sample	40	6/2/95	25.2	26.2
Sample	41	6/3/95	23.0	27.2
Sample	42	6/4/95	22.9	28.2
Sample	43	6/5/95	24.0	29.2
Sample	44	6/6/95	23.7	30.1
Sample	45	6/7/95	23.3	31.1
Sample	46	6/8/95	25.3	32.2
Sample	47	6/9/95	23.3	33.1
Sample	48	6/10/95	24.1	34.1
Sample	49	6/11/95	24.5	35.2
Sample	50	6/12/95	23.9	36.1
Sample	51	6/13/95	0.2	36.2
End		6/13/95	1	l

While this regime provided small samples of effluent allowing detailed analysis of effluent concentrations during the first few hours of injection, it gave large samples of effluent later in the experiment when concentrations were low and changing slowly. To minimize sample degradation, an ice bath surrounded each bottle while collecting the effluent. As each bottle filled, it was sealed with a Teflon cap and placed in a refrigerator at 4 °C (± 2 °C) or an ice bath to prepare for transport to the analytical laboratory.

The pressure in the sample holder was cycled throughout the injection using a timer on a solenoid valve at the outlet end of the sample holder. The valve functioned to close the outlet for one hour and open it for thirty minutes while maintaining steady steam flow into the inlet. Because the steam flow was maintained into the inlet of the one-dimensional test cell but the outlet was closed, pressures within the test cell increased. At these increased pressures the system continued to deliver steam at a higher saturated temperature. Thus increasing the pressure also increased the temperature in the test cell. The steam pressure was allowed to reach 30 psig before the outlet valve was opened. This depressurization of the system to values near atmospheric pressure enhances the vaporization of the interstitial water and volatile hydrocarbon components in regions not otherwise affected by flowing steam. The pressurization/depressurization cycle had a period of thirty minutes and was performed on the test cell from the time sample 18 was taken until the end of the experiment. During steam cycling, the effluent tube was placed in an ice bath to condense the effluent before it reaches the sample bottle.

On the sixteenth day of steaming, the steam generator developed a leak. The experiment was temporarily shut down and the test cell was flooded with water, capped and refrigerated. While the steam generator was being repaired, the test cell remained in the refrigerator for a period of nine days. When the cell was removed, water which had been placed in the test cell and allowed to equilibrate with the residual contaminants was flushed out using nitrogen gas. Sample 29 consisted of this collected effluent. Steaming resumed with Sample 30. The total amount of water heated to steam and injected into the test cell over the 36 days of injection was 32.9 liters. This can be related to a field scale steam injection by equating pore volumes of condensate recovered. For the test cell used in this experiment, 32.9 liters is 330 pore volumes of steam condensate.

3. LABORATORY ANALYSES PERFORMED

The soil and effluent samples were sent to Curtis and Tompkins, Ltd. Analytical Laboratories (Berkeley, CA) for chemical analysis. The soil samples taken from the site were analyzed for TEH (EPA method 8015), PAH (EPA method 8270) and metals (EPA method 6010). Effluent samples were analyzed for TEH (EPA method 8015), PAH (EPA method 8270) and pH (EPA 9040). Table 3-1 below summarizes the samples analyzed and the methods employed.

Table 3-1. Samples Analyzed and Methods Employed

	TEH (Method 8015)	PAH (Method 8270)	Metals (Method 6010)	pH (Method 9040)
Original Soil	V	√	7	
Post-Steam Soils #1-9	V		√	
Effluent #1	1		,	V
Effluent #2-41,43-50	√			
Effluent #51	7			V

4. EXPERIMENTAL RESULTS

4.1 Untreated Soil

The untreated soil was heavily contaminated with crude oil-like petroleum hydrocarbons in concentrations of 32,000 parts per million (ppm) in the diesel and motor oil range. Longer and shorter chained hydrocarbons outside of the diesel and motor oil range are not included in the analysis, and thus the actual concentration was larger. The Method 8015 chromatogram and the Method 8270 chromatogram show that the distribution of hydrocarbons is spread from retention times of 5 min. to 30 min., which corresponds to straight-chain hydrocarbons from C14 to C44.

The PAH analysis (EPA Method 8270) showed all compounds of concern to be below detection limits; however the detection limits of individual components were quite high (50 ppm to 250 ppm). Thus, no conclusions can be drawn regarding the presence or absence of compounds of health concern.

The metal analysis (EPA Method 6010) showed moderate levels of Chromium (20 mg/kg), Copper (110 mg/kg), Lead (38 mg/kg), Nickel (21 mg/kg), and Zinc (57 mg/kg).

4.2 STEAM TREATED SOIL

While there was a dramatic compositional change in the waste oil after being subjected to steam flow, the actual concentrations remained high in the motor oil range as shown in Table 4-1. The location of each sample is referenced to the distance from the test cell outlet. Therefore sample S1 represents steamed soil taken between 0 inch and 1 inch from the outlet, sample S2 represents soil taken between 1 inch and 2 inches from the outlet, etc.. Sample S0 is untreated soil identical to that placed in the test cell. It serves as a representative control for soil chemistry before steam treatment.

Table 4-1. Soil Hydrocarbon Concentrations

LAB ID	Sample ID	Diesel Range (mg/kg)	Motor Oil Range (mg/kg)
121413-001	SO T	$12,000^2$	20,000 ²
121413-002	S1@1"	1,600	25,000
121413-003	S2@2"	1,500	30,000
121413-004	S3@3"	490	30,000
121413-005	S4@4"	ND(300)	23,000
121413-006	S5@5"	ND(400)	12,000
121413-007	S6@6"	ND(930)	21,000
121413-008	S7@7"	ND(930)	35,000
121413-009	S8@8"	ND(1,900)	33,000
121413-010	S9@9"	ND(880)	36,000

So Bunker C Range concentration was 57,000 mg/Kg, and chromatogram resembled the Bunker C standard.

The chromatograms for the steamed soil show interesting trends of the preferential removal of the shorter retention time hydrocarbons (more volatile) except for soils from locations near the inlet and outlet of the test cell where anomalous peaks were observed at the chromatographic retention times in the 14 min. to 18 min. range (S9 and S1). These peaks are presumed to be due to end effects of vapor fluxes inside the test cell due to heat losses at the end caps, or waste oil in soils in the test cell corners which may not have seen representative steam fluxes.

The metal analysis (EPA Method 6010) of all soils, presented in Table 4-2, showed no appreciable change in the levels of Beryllium, Cadmium, Chromium, Copper, Lead, or Nickel. Mercury was detected in the untreated soil, but not in the treated soils. Since mercury is a relatively volatile metal, its removal, and thus presence in extracted fluids, is expected. Arsenic and Zinc concentrations may also have been reduced by the steaming process.

Sample Chromatogram did not resemble hydrocarbon standard.

Table 4-2. Soil Metals Concentrations

	Arsenic	•		Chromium		Lead	Mercury		Zinc
	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
SO	1.50	0.16	0.3	20	110	38	0.13	21	57
S1@1"	0.80	0.13	0.33	20	94	60	ND(0.4)	21	49
S2@2"	0.69	0.15	0.33	21	38	0	ND(0.1)	20	33
S3@3"	0.82	0.13	0.3	18	75	. 100	ND(0.1)	20	18
S4@4"	0.67	0.14	0.32	21	130	70	ND(0.1)	21	22
S5@5"	0.77	0.13	0.29	19	130	61	ND(0.1)	20	19
S6@6"	1.00	0.15	0.3	21	110	72	ND(0.1)	22	26
S7@7"	0.99	0.14	0.28	21	54	55	ND(0.1)	21	32
S8@8"	0.83	0.14	0.33	24	49	83	ND(0.1)	21	33
S9@9"	0.83	0.15	0.38	25	42	71	ND(0.1)	21	32

4.3 AQUEOUS EFFLUENT

The effluent analyses results (EPA Method 8015) are summarized in Table 4-3. The concentrations are highest in the first 12 samples, and decrease significantly thereafter. Also reflected in these numbers is the trend of increasing retention times of the hydrocarbons found in the effluent with the time of steaming. This trend shows up in the shift from compounds in the diesel range to the longer retention time motor oil range. The numbers reported, while self-consistent, are not fully representative of the effluent concentrations due to the limited range of the diesel and motor oil standards.

4-3. Effluent Analyses

LAB ID	Sample ID	Diesel Range	Motor Oil Range
		(mg/kg)	(mg/kg)
121433-001	E-1	23	ND(16)
121433-002	E-2	3,400	ND(1,300)
121433-002	E-3	110	ND(16)
121433-004	E-4	33,000	ND(3,100)
121433-005	E-5	2,100	ND(300)
121433-006	E-6	2,100	ND(250)
121433-007	E-7	3,200	ND(830)
121433-008	E-8	1,500	ND(180)
121433-009	E-9	1,700	ND(170)
121433-010	E-10	6,600	ND(830)
121433-011	E-11	2,200	. ND(480)
121433-012	E-12	4,800	ND(480)
121433-013	E-13	80	ND(13)
121433-014	E-14	180* 560*	ND(57) ND(150)
121433-015 121433-016	E-15 E-16	220*	ND(130) ND(140)
121433-010	E-10 E-17	340*	56*
121433-017	E-18	230*	300*
121433-019	E-19	110*	120*
121433-020	E-20	65*	46*
121433-021	E-21	68*	49*
121433-022	E-22	51*	39*
121433-023	E-23	48*	36*
121433-024	E-24	34*	30*
121433-025	E-25	29*	63*
121433-026	E-26	23*	22*
121433-027	E-27	19*	17*
121433-028	E-28	38*	25*
121433-029	E-29	4.1*	ND(16)
121433-030	E-30	18*	16* 27*
121433-031	E-31	42*	
121433-032	E-32 E-33	18* 8.8*	16* 15*
121433-033 121433-034	E-33 E-34	14*	29*
121433-034	E-34 E-35	8.8*	36*
121433-036	E-36	7.9*	39*
121433-037	E-37	6.4*	30*
121433-038	E-38	4.8*	37*
121433-039	E-39	4.5*	37*
121433-040	E-40	4.7*	44*
121433-041	E-41	3.8*	39*
121433-042	E-43	9.2*	60*
121433-043	E-44	4.1*	35*
121433-044	E-45	14*	29*
121433-045	E-46	0.92*	29*
121433-046	E-47	1.2*	25*
121433-047	E-48	1.1*	24*
121433-048	E-49	1.1*	23*
121433-049	E-50	2.3*	40*
121433-050	E-51	2.2*	e hydrocarbon standard

*Sample chromatogram does not resemble hydrocarbon standard.

Figure 4-1 is a three-dimensional representation of the detector response as a function of retention time for each analyses, stacked in depth to show trends with respect to sample number (time). Figure 4-1 clearly shows the shift in composition with sample number from shorter retention time components at the beginning, to longer-chained, greater retention time compound at the later stages of the treatability test. It is also clear from this plot that the bulk of the recovered hydrocarbon mass was removed during the first fraction of the experiment.

4.4 CUMULATIVE MASS REMOVED

The cumulative mass removed was calculated by multiplying the total concentrations of hydrocarbons (diesel range plus motor oil range values) by the total mass of liquid in the effluent sample, and summing all sample hydrocarbon mass values. The cumulative mass removed was thus found to be 9 grams. The trend with cumulative steam condensate recovered is plotted in Figure 4-2. As shown in Figure 4-2, most of the hydrocarbon mass was removed during the first fifth of the experiment. Thereafter, the mass removal rate was small due to the low volatility of the compounds remaining in the soil. It is of note that the removal rates during the later parts of the experiment were comparable to those that might be expected during isothermal groundwater pumping.

4.5 PH ANALYSES

pH analyses were performed on Samples E-1 and E-51, the results are summarized in Table 4-4. Since the volume of water drained from the test column after 9 days of refrigeration (E-29) was small, insufficient water was available to perform EPA Method 9040. Enough water was available to test pH using litmus paper however, and that value is presented in the following table along with those of E-1 and E-51.

Sample ID	pН
E-1	2.1
E-29	6-7*
E-51	6.3

Table 4-4. pH of Effluent Fluid

From these analyses, it appears that the steaming process increases the pH of the water in equilibrium with the waste oil from very acid conditions to neutral values. This pH neutralization seems to occur early in the steaming process rather than later. The conclusions that can be reached from this data are limited. Since the treatability study was not designed to specifically measure the effects of steam injection on the soil pH, the amount of data collected was confined to two samples. More detailed analysis of the effluent and soil pH will be performed in the second laboratory study to better characterize this property.

The source of the low pH in soils and associated water samples is not known. However, the low pH does show that a readily soluble source of acid constituents is available (recall that pH is a measure of hydrogen ion concentration.) It is very reasonable that steam-treating the oily material in soil extracts the soluble acidic constituents which are then displaced with the soil pore water ahead of the steam front. The efficient, steam enhanced extraction of these constituents then removes the acid-generation potential from these soils,

^{*}value obtained from litmus test

resulting in more neutral pH values for the treated soils; it should also be noted that the organic acids in the oily material are not a likely source of the low pH values as organic acids have pKa values of around 5 (like acetic acid), an the pH due to remaining organic materials is limited by the solubility of these high molecular weight acids.

5. ENERGY COSTANALYSIS

The result of the treatability test show decreasing recovery rates with time as the more volatile compounds are first removed and the less volatile compounds remain. Extrapolation of the data and trends to extremely long times indicates that a substantial fraction of the hydrocarbon mass may be removed, but at the cost of very large steam volumes. To bring these results to a form appropriate for field-scale evaluation, the steam condensate mass is normalized to the test cell pore volume, defined as the internal volume of the test cell multiplied by the soil porosity. Since the porosity of the highly contaminated soil could not be measured, it is assumed to be 40% for the purpose of analysis. The fraction of the initial hydrocarbon mass that was removed during the steaming process was calculated from the total mass of hydrocarbon removed during the steaming process divided by the initial hydrocarbon mass in the soil (soil mass multiplied by the Bunker C concentration of 57,000 mg/Kg) A plot of the fraction of original hydrocarbon mass removed vs. the number of pore volumes of steam condensate collected is provided in Figure 4-3. Note that Figures 4-2 and 4-3 have the same basic shape. Since the steam distillation rate drops off exponentially for long-term steam distillation, the fraction of oil removed for condensate pore volumes greater than 20 will not vary significantly from those shown for soil concentrations less than 57,000 mg/kg.

The energy cost per unit volume of soil for the steaming process is proportional to the pore volumes of steam injected which is linearly related to the pore volumes of steam condensate. The costs can thus be calculated from the following equation which was derived from a energy and mass balances.

 $\$/yd^3 = \$/MBtu x (pore volumes condensate) x .7555$

The factor, .7555 is the porosity (0.4) multiplied by the water density (62.3 lbm/ft³) multiplied by the difference between the steam enthalpy and the inlet water enthalpy (1.1228 x 10⁻³ MBtu/lbm), and the conversion factor between cubic feet and cubic yards (27 ft³/yd³).

Using the equation above, the energy cost associated with a given fraction of hydrocarbon recovery can be obtained from the data of Figure 4-4. The analysis was performed for two energy costs, one with quoted steam costs at Alameda (\$13.52/Mbtu) and the other for field SEE operation at LLNL during the summer of 1993 (\$3.8/Mbtu). Figure 4-4 can be used to estimate the expected cost for recovering a specified fraction of the hydrocarbon mass from soil contaminated with oil at a concentration of 45,000 ppm. As shown in the figure, 25% of the oil mass can be removed for about \$20/yd³ in energy cost if commercial rates for an energy source are paid. However, Alameda steam costs would be over \$100/yd³ for the same level of removal.

While this analysis is based on the composition and assumed concentration of the oil in this single soil sample, its implications are clear. First, complete removal of the hydrocarbon phase from this site by steam distillation would be prohibitively expensive. Second, mobilization and capture of the liquid oil will be much more effective in removing oil mass than steam distillation. Third, if pH increase is considered to be a priority function of the in

situ cleanup of this site, then steam injection of relatively short duration may be valuable. Indeed, the expectedly low pH of site water may be responsible for the very small microbial populations observed in the oil-free soils sampled thirty feet from the location of the hydrocarbon laden soil used in these treatability tests. Thus pH reduction maybe necessary before biodegradation reactions can occur to any significant extent.

6. CONCLUSIONS

Based on this laboratory treatability test, Steam Enhanced Extraction alone will not be capable of removing the low-volatility components of the waste oil without exorbitant energy costs. Up to 25% of the waste oil may be removed from the soil for a commercial energy cost of \$30/ yd³ of treated soil. SEE does have the ability to restore the soil water to neutral pH from an initial effluent sample pH of 2.1, and reduced the aqueous phase hydrocarbon concentrations by a factor of 5.6 at a point half way through the treatability test.

7. QUALITY ASSURANCE/QUALITY CONTROL

All water injected into the sample holder was distilled and then boiled to reduce the amount of dissolved gas. The water used was distilled in a stainless steel distillation unit as a precautionary measure. Because the solubility of gasses decreases with increasing temperature, boiling the water before injection reduces the amount of dissolved gasses. Without this step, an unknown amount of gasses other than water would come out of solution in the boiler and flow through the steamed sand pack with the steam. For the field studies, NAS Alameda standard procedures for generating steam are such that solution gasses in the boiler feed-water would also be reduced. The boiling procedure in the laboratory simply represents a further control on the bench study in which small amounts of soil are used since dissolved gas would carry mass from the system in an unaccounted fashion. All tubing used to carry the water and effluent was made of Teflon in order to avoid contamination by interaction with the tube material. To minimize the chance of system contamination, the system remained closed throughout the experiment except for the necessary introduction of water to the metering pumps and the changing of the sample bottles.

All sample bottles were prepared by washing with nonphosphate detergent followed by multiple tap water and distilled water rinses. After washing, the bottles were oven-dried and sealed with Teflon caps. Sample bottles were kept in an ice bath while the effluent was being collected to keep the temperature low and minimize potential losses due to evaporation. Filled sample bottles were capped with a Teflon cap and placed in either a refrigerated space or into a cooler containing ice to maintain temperatures at 4 °C (± 2 °C).

Each cooler contained a method blank consisting of distilled water from the same source as that used in the metering pumps. The method blank should have indicated any contamination in the preparation, storage, and transportation of the samples. All samples were packed with foam and ice prior to transportation. Samples from the treatability study were shipped for analysis on 6/15/95, two days after the experiment ended. Samples were not sent during the experiment because it is BERC practice to send all treatability test samples for analysis in one batch to minimize analytic variation associated with differences in laboratory calibrations, chromatographic columns, and equipment changes. The samples were not analyzed within the 14-day holding period specified by U.S. EPA methods because the duration of the experiment exceeded this time. The sample degradation from this extended holding time should be minimal because high hydrocarbon concentrations were identified in the samples and gas chromatography indicated the compounds present in

the effluent were hydrocarbons with low volatility. Each cooler contained a chain of custody form and was sealed with custody tape.

8. **RECOMMENDATIONS**

While the results of this treatability test showed that steam cannot economically distill the heavy hydrocarbon components of the waste oil from Site 13 soils, the data obtained from the study has been very valuable in knowing the limits of field performance, both economic and effectiveness. Within those limits, there is much value to be gained in the restoration of this site through the application of SEE. Particularly, the removal of the most volatile fraction of the hydrocarbon mass, and the restoration of the site to neutral pH may be possible at modest cost. These changes may have sufficient effect on contaminant mobility and future hydrocarbon biodegradation rates to allow the risk-based cleanup needs to be met without further active processing. Thus, it is recommended that an additional short duration treatability test be run to assess the effect of SEE on the leachability of the hydrocarbons and PAHs, if present, and the pore water pH. These tests are to be run in accordance with the Laboratory Treatability Study section of this work plan.

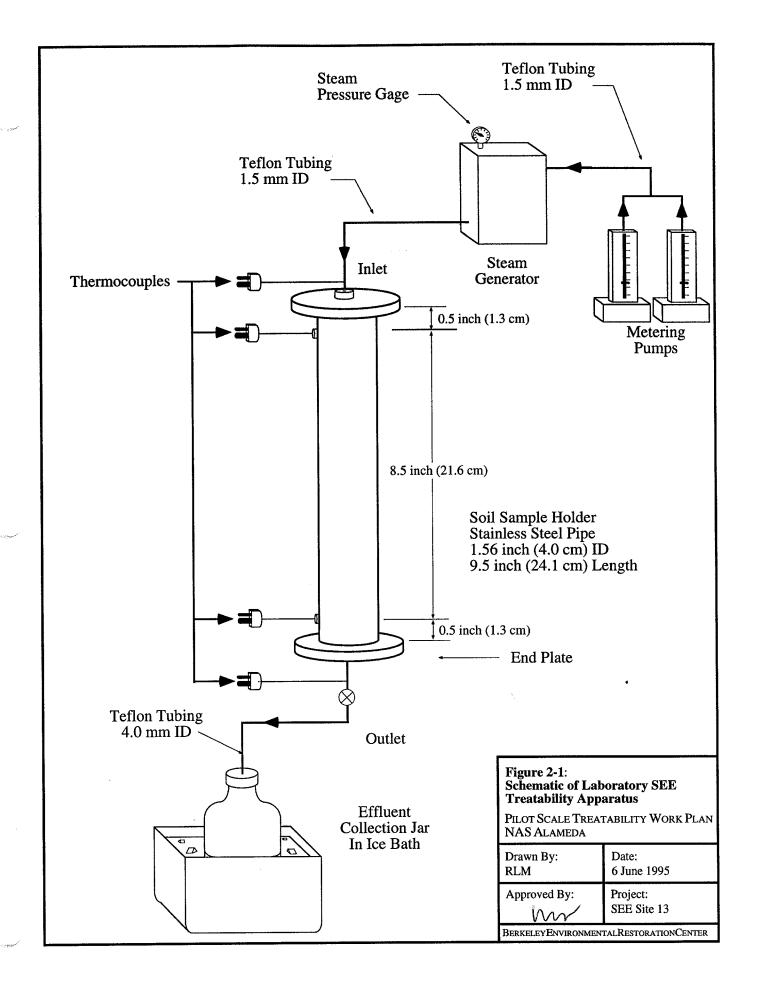


Figure 4.1 Effluent Liquid Chromatograms for the 1-Dimensional Steaming of Contaminated Soil

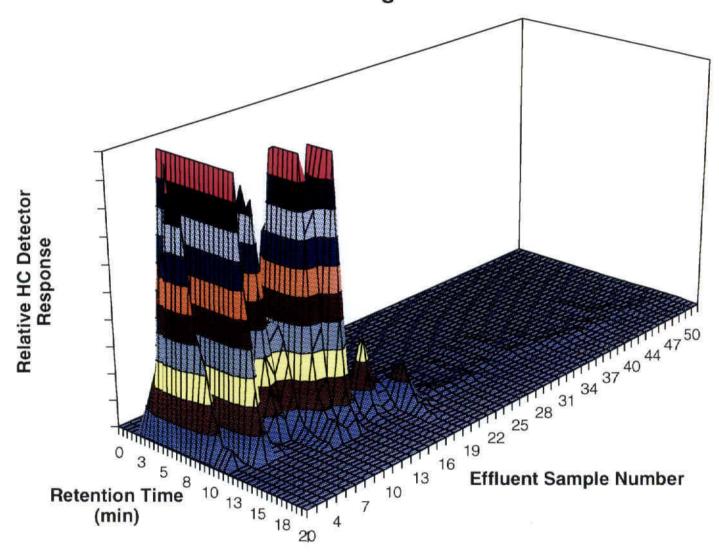


Figure 4.2. Petroleum Removed vs Effluent Mass

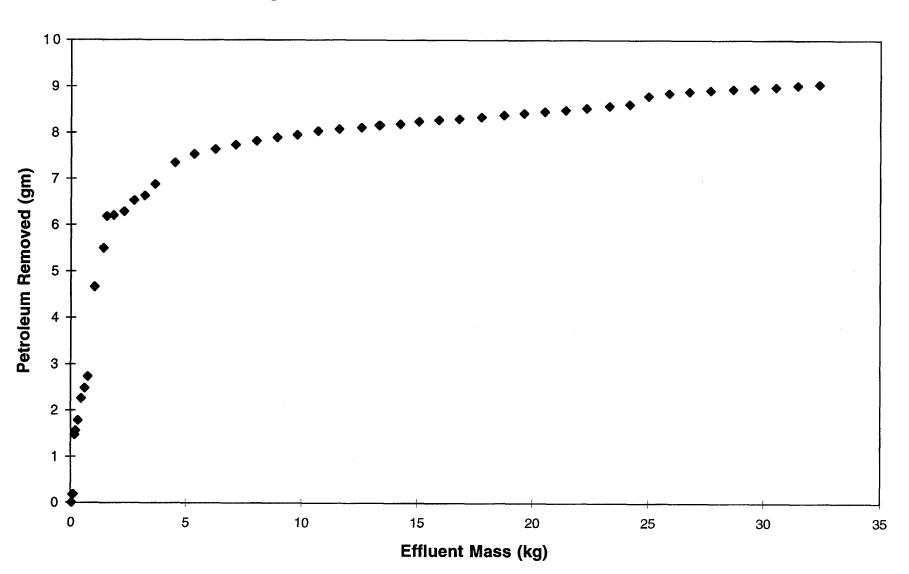


Figure 4.3: Petroleum Removed vs Pore Volumes Condensed

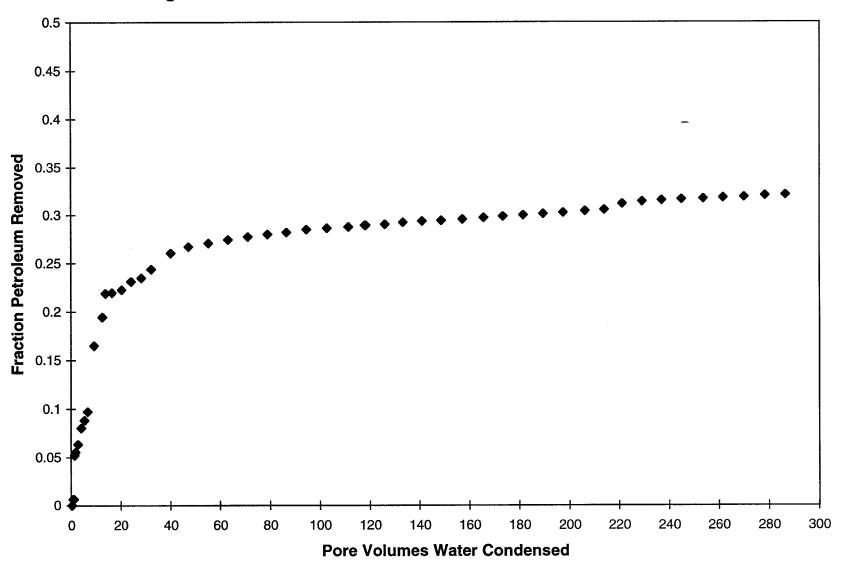
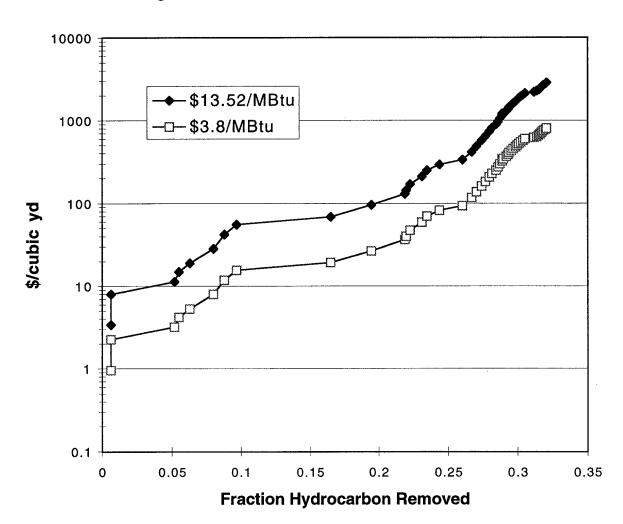


Figure 4.4. Cost of Steam vs. Fraction Oil Removed



APPENDIX C

RESULTS OF LABORATORY TREATABILITY TEST FOR LEACHABLE HYDROCARBONS

PILOT-SCALE TREATABILITY WORK PLAN STEAM ENHANCED EXTRACTION SITE 13 NAVAL AIR STATION ALAMEDA ALAMEDA, CALIFORNIA

APPENDIX C RESULTS OF LABORATORY TREATABILITY TEST FOR LEACHABLE HYDROCARBONS

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PILOT-SCALE TREATABILITY WORK PLAN

STEAM ENHANCED EXTRACTION SITE 13 NAVAL AIR STATION ALAMEDA ALAMEDA, CALIFORNIA

APPENDIX C RESULTS OF LABORATORY TREATABILITY TEST FOR LEACHABLE HYDROCARBONS

Revision 1

UNCLASSIFIED March 20, 1996

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2-1 Schematic of Laboratory SEE Treatability Apparatus

1. INTRODUCTION

Previous laboratory treatability and field tests of the applicability of steam enhanced extraction (SEE) to relatively low volatility hydrocarbon mixtures such as JP-5 fuel and utility pole treatment tars conducted at the Berkeley Environmental Restoration Center (BERC) Laboratory of the University of California, Berkeley showed effective removal of those liquid compounds from the soils. The tests reported herein examine whether or not SEE will be effective in removing the still lower volatility oily material from Site 13 soils. Since reductions in the concentrations of the most volatile compounds may be sufficient to reduce potential health risks to acceptable values, the potential extent for removal of the various components from the oily material of these soils by SEE as well as the composition of the residual hydrocarbons are of interest. Furthermore the steaming process may neutralize the acidic conditions and stabilize the metals at the site.

A laboratory treatability test for total hydrocarbons (Appendix B of the Work Plan) was conducted in order to better define the characteristics of the effluent liquids and residual oily material. Results from an energy cost analysis demonstrated that complete restoration of the site by steam distillation would be cost prohibitive. However, the removal of the most volatile fraction of the hydrocarbon mass and the restoration of the site to neutral pH was predicted to be possible at a commercial energy cost of approximately \$20/yd. These changes may sufficiently decrease contaminant mobility and increase future hydrocarbon biodegradation rates to allow the procedure to meet cleanup goals.

In order to further evaluate the ability of SEE to remove mobile hydrocarbons from the oily material matrix at Site 13 and assess the process effect on soil and pore water pH, an additional short-duration laboratory treatability test was performed. This second laboratory treatability test objective was to determine the extent of constituent removal by SEE. Results from chemical analyses from this experiment demonstrate that SEE effectively removed the lighter hydrocarbon fractions including benzene, toluene, ethylbenzene, and xylene, even though the total hydrocarbon mass removal was relatively small. Thus, only the less mobile, higher molecular weight fractions of the oily material remained as residuals. In addition, analyses showed an apparent reduction in the leachability of some metal constituents as well as the ability of SEE to restore pore water to near-neutral pH conditions.

2. EXPERIMENTAL PROCEDURE

2.1 EXPERIMENTAL SETUP

As shown in Figure 2-1, the apparatus for the one-dimensional treatability experiment consisted of a 4 ft long Pyrex glass column packed with contaminated soil. In order to maintain nearly adiabatic conditions, the sand pack was surrounded by heater tapes and insulated. Two 100 Ω heaters were attached to the end plates at both the inlet and outlet and 6.5 Ω heater tapes were wrapped around the exterior of the column's radial surface. Both stainless steel end plates had channels engraved on their inner surface and were covered with stainless steel screens in order to promote uniform steam spreading across the sample cross section.

The experimental setup incorporated a pair of metering pumps to deliver a constant mass flow rate of distilled water, a steam generator to boil the water into steam, a timer controlled solenoid valve used in pressure cycling, and an effluent collection jar maintained in an ice bath to minimize loss of components from the effluent to the atmosphere. Steam flow rates

were set by the water pumping rates into the steam generator. Thermocouples were mounted at the steam inlet and outlet ports as well as on the glass surface at three equally spaced points. Teflon tubing was used to carry all fluids into and out of the system and was long enough to allow the effluent to cool to near room temperature. To ensure condensation of the effluent prior to collection, an ice bath condenser stage was added to the outlet tubing.

2.2 SOIL SAMPLE PREPARATION

Soil samples were collected with a Geoprobe ® System from three locations at Site 13. Borehole samples were distributed into separate categories based on their extent of contamination. Brown (B) samples were characterized as relatively uncontaminated soils taken primarily from above the capillary fringe. Grey (G) samples consisted of partially saturated oily sands and clays. Product (P) samples were those saturated with oils and water. Prior to mixing the soils, one sample of each type was sent to an outside laboratory for chemical analysis. In order to reduce hydrocarbon vapor pressure, grey and product samples were first chilled overnight and then mixed at a 50:50 ratio to uniformly distribute the oily material within the mixture (M) sample. Prior to packing the column, a sample of this mixture was also sent for chemical analysis. To ensure sample homogeneity and pretreatment soil data confidence, duplicate samples of the unmixed and mixed soil were also sent for analysis.

The contaminated soil mixture was packed into the glass column by alternately adding a few centimeters of soil and compacting the matrix with a wooden dowel in order to reduce void spaces in the pack. Packing continued until enough material was in place that the contents were slightly compressed when the end cap was bolted in place. This compression further minimized voids created during settling of the sand pack. To reduce end effects, two inches of clean sand was packed at both the inlet and outlet ends of the sand pack.

2.3 PRE-STEAMING LEACHABILITY STUDY

Before steam injection was initiated, the sand pack was flooded with distilled, de-ionized and de-aerated water, and sealed. After a period of five days to allow thermodynamic equilibrium conditions to become established at room temperature, the water was drained and sent for chemical analysis.

2.4 STEAM INJECTION PROCEDURE

In order to limit steam use to values equivalent to an energy cost of approximately \$20/yd³, 8 pore volumes of water were pumped into the steam generator: the vaporized water then flowed into the column. Steam injection flow rates were gradually increased from the beginning of the experiment and were eventually stabilized at 40 milliliter per hour (mL/hr) to prevent initial pressure build-up within the glass column.

To minimize sample degradation, effluent sample bottles were placed in an ice bath during collection. During the steaming period, effluent samples were collected according to the schedule shown in Table 2-1. Each filled sample bottle was sealed with a Teflon cap and placed in a refrigerator at 4°C (± 2°C) or an ice bath prior to being sent to the analytical laboratory for chemical analysis.

Table 2-1 Effluent Sampling Schedule.

Sample	Sample Time (day)	Cumulative Time (day)	Sample Volume (mL)	Cumulative Volume (mL)
1E	3.73	3.73	889	889
2E	0.83	4.56	637	1,526
3E	0.40	4.96	791	2,317
4E	0.90	5.86	807	3,124
5E	0.78	6.64	869	3,993
6 E	0.83	7.47	752	4,745
7E	0.26	7.73	370	5,115
8E	1.32	9.05	818	5,933
9E	0.92	9.97	817	6,750
10E	0.74	10.71	985	7,735

Throughout steam injection, the pressure in the sand pack was cycled over approximately one hour from atmospheric to about 10 pounds per square inch gauge (psig) using a timer on a solenoid valve at the outlet end of the glass column. Upon closure of the valve, the pressure within the soil matrix accumulated causing an increase in temperature. As such, when the valve was opened and pressures returned to ambient, a portion of the pore water was vaporized and thus contaminant volatilization was augmented. This cycling process served to vaporize contaminants trapped in less accessible regions such as dead end pores.

2.5 POST-STEAMING LEACHABILITY STUDY

At the end of steam injection, the sand pack was slowly cooled to ambient temperature and again flooded with distilled, de-ionized and de-aerated water and sealed. After a period of five days to allow thermodynamic equilibrium conditions to re-establish at room temperature, the water was then drained and sent for chemical analysis.

Once the leachability study water was drained from the sand pack, the glass column was chilled for 24 hours in order to reduce hydrocarbon vapor pressure. After cooling, the soil within the column was removed and separated into four samples, one from each foot of the sand pack. All four samples were then sent for chemical analysis. To ensure sample homogeneity and consistency of analytical data, duplicate samples from each section of the soil were also sent for analysis.

3. LABORATORY ANALYSES PERFORMED

All soil, effluent and leachability samples were sent to a California state certified and Navy-approved laboratory (Curtis and Tompkins, Ltd., Berkeley, CA). Samples analyzed and methods employed are summarized in Table 3-1.

Table 3-1 Summary of Chemical Analyses

Analysis (EPA Method)	Soil	Effluent	Leachability
Total Extractable Hydrocarbons (8015)	х	х	х
Total Volatile Hydrocarbons (8015)	x	х	1
BTEX (8020)	х	х	
BTEX-TCLP (8020)	. X		
Polycyclic Aromatic Hydrocarbons (8270)	х	Х	X
PAH-TCLP (8270)	x		
Metals (6010/7471)	х		
Metals-WET (6010/7471)	x		
pH (9045/9040)	х	х	х
Chloride/Sulfate (325/375)	x	x	

3.1 HYDROCARBON ANALYSIS

The oily material that is present in site soils is believed to be a waste product residual from the refinery that ceased operations in the early 1900's. Preliminary characterization of its chemical composition was provided in the laboratory treatability test for total hydrocarbons (Appendix B of the Work Plan). Its physical properties such as viscosity and density at various temperatures are not available because a representative liquid sample has not been obtained. It is expected that waste residuals at Site 13 would largely consist of higher molecular weight, very low water solubility components of crude oil, with most of the lighter constituents having been removed by distillation during processing and then by weathering over the some 90 years since disposal at the site.

Because of the residual and weathered nature of the oily material, no suitable standards are available for accurately quantifying the hydrocarbon fractions associated with the oily materials in the untreated and steam-treated soils. As such, amounts of hydrocarbon contaminant were categorized according to an assumed carbon range content using the known hydrocarbon standards of kerosene, diesel and motor oil as analyzed by gas/liquid phase chromatography. Data for these standards are listed in Table 3-2, and their respective chromatograms are shown in as Figures 3-1 through 3-4. Table 3-2 also lists Bunker C, which was considered as a possible standard for this treatability study. However, since Bunker C is a mixture of a non-boiling distillate residual and a distillate fraction (often diesel) that achieves desired physical properties, it has a broader range of constituents than other standards. Therefore, the fractions corresponding to kerosene, diesel and motor oil were considered as being most applicable for categorizing the hydrocarbon materials present in the soil, effluent and extract samples.

Table 3-2 Hydrocarbon Standards.

Hydrocarbon Standard	Carbon Range Based on n-Alkane	Chromatographic Retention Time (min.)
Kerosene	C10-C12	2-4
Diesel	C12-C22	4-12.5
Motor oil	C22-C50	12.5-31
Bunker C oil	C12-C50	4-31

Areas under the chromatograms within the retention time intervals were first calculated and the amount of hydrocarbon in the interval estimated using the measured response factor (hydrocarbon per unit area) for the standard in the same interval. This procedure provided a consistent means of comparing the relative amounts of hydrocarbon present in the various samples analyzed. The use of the response factors for the hydrocarbon standards is not strictly applicable for quantifying the yet unknown hydrocarbon material present in the oily material.

3.2 LEACHABILITY ANALYSIS

Analyses for specific benzene, toluene, ethylbenzene, and xylene (BTEX), polycyclic aromatic hydrocarbon, and metal constituents in the soils containing oily material were performed on the untreated and steam-treated soils. The soils were also tested using standard extraction tests; organic constituents and hydrocarbon fractions were extracted from soils using the U.S. EPA's Toxicity Characteristic Leaching Procedure (TCLP), and metals were extracted using the California EPA's Wet Extraction Test (WET). These extraction tests use an active mixing of soil and extracting solution for several hours. As these extraction tests are more aggressive over a short time period than would be experienced in site soils exposed to water via infiltration, they therefore overestimate the expected leachability of constituents.

4. EXPERIMENTAL RESULTS

4.1 UNTREATED SOIL

Borehole soil samples collected Site 13 were initially distributed into separate categories based on their extent of contamination. While brown (B) samples were characterized as relatively uncontaminated soils taken primarily from above the capillary fringe, grey (G) samples consisted of partially saturated oily sands and clays and product (P) samples were those saturated with oils and water. The untreated soil used in this experiment (M-S1) consisted of an equal mixture of grey (G-S1) and product (P-S1) soil samples. All chemical analyses for M-S1 consistently showed the mixture to be a uniform distribution of these two original samples.

The untreated soil is believed to be contaminated with oily material from refinery residuals. Since it has not been characterized for its chemical composition or physical properties, the amounts of hydrocarbon contaminant were categorized according to an apparent carbon range content using the known hydrocarbon standards of kerosene, diesel and motor oil as analyzed by gas/liquid phase chromatography. As shown in Table 4, total extractable hydrocarbon (TEH) analysis performed on the untreated soil (M-S1) found it to predominantly contain petroleum hydrocarbons in the diesel and motor oil ranges, corresponding to straight-chain hydrocarbons from C12-C50. Elevated reporting limits noted by parentheses were due to an inability to analyze the concentrated sample extract. Of note is the relative absence of the lighter fractions of the oily waste in the sample recovered from the vadose zone (B-S1) as compared to the samples taken from the deeper, saturated zones. This difference is attributed to vaporization and/or biodegradation processes which would have occurred during the 90 years since the oil refinery operations ceased. Respective chromatograms for all the untreated soils are shown in the Appendix as Figures 4-1 through 4-4.

Table 4-1 Untreated Soil, TEH Results (EPA Method 8015).

	B-S1 (mg/kg)	G-S1 (mg/kg)	P-S1 (mg/kg)	M-S1 (mg/kg)
Kerosene Range (C10-C12)	(120)	(1,400)	(36,000)	(13,000)
Diesel Range (C12-C22)	(120)	3,000	47,000	24,000
Motor Oil Range (C22-C50)	1,700	2,200	49,000	25,000

As presented in Table 4-2, analysis of the untreated soils for the more volatile constituents showed detectable amounts of BTEX constituents as well as total volatile hydrocarbons (TVH) in soils recovered from deeper zones. Consistent with the findings presented in Table 4-1, the shallow soil (B-S1) volatile components were relatively absent. In addition, analysis using TCLP for BTEX constituents also gave detectable quantities of BTEX in the untreated soil leachate as shown in Table 4-3. Also of note is the trend towards higher BTEX content with depth from the site surface.

Table 4-2 Untreated Soil, BTEX/TVH Results (EPA Methods 8020/8015).

	B-S1 (μg/kg)	G-S1 (μg/kg)	P-S1 (μg/kg)	M-S1 (μg/kg)
Benzene	< 5	12	260	190
Toluene	< 5	130	1,100	840
Ethylbenzene	< 5	34	170	110
Xylene	< 5	289	1,350	930
Gasoline Range	< 1000	6,500	15,000	9,600

Table 4-3 Untreated Soil, BTEX-TCLP Results (EPA Method 8020).

	B-S1 (μg/L)	G-S1 (μg/L)	P-S1 (μg/L)	M-S1 (μg/L)
Benzene	< 0.5	< 0.5	33	18
Toluene	< 0.5	7.7	130	82
Ethylbenzene	< 0.5	2.3	15	11
Xylene	< 0.5	22	127	100

Analysis for polycyclic aromatic hydrocarbons (PAH) showed detectable amounts of naphthalene, fluorene, phenanthrene, pyrene, and chrysene in the untreated soil (M-S1) as shown in Table 4-4. Values in parentheses are below the reporting limit of 5,000 parts per billion (ppb) but above the detection limit. TCLP analysis for PAH constituents reported all quantities below the detectable limit of 500 (ppb) for all four untreated soils.

Table 4-4 Untreated Soil, PAH Results (EPA Method 8270).

	B-S1	G-S1	P-S1	M-S1
	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)
Naphthalene	< 50	< 1,000	13,000	(4,800)
Acenaphthylene	< 50	< 1,000	< 5,000	< 5,000
Acenaphthene	< 50	< 1,000	< 5,000	< 5,000
Fluorene	< 50	(540)	19,000	7,100
Phenanthrene	< 50	1,600	61,000	22,000
Anthracene	< 50	< 1,000	(3,700)	< 5,000
Fluoranthene	< 50	< 1,000	(4,100)	< 5,000
Pyrene	< 50	< 1,000	9,400	(4,100)
Benzo(a)anthracene	< 50	< 1,000	5,300	< 5,000
Chrysene	< 50	(540)	14,000	(4,900)
Benzo(b)fluoranthene	< 50	< 1,000	< 5,000	< 5,000
Benzo(k)fluoranthene	< 50	< 1,000	< 5,000	< 5,000
Benzo(a)pyrene	< 50	< 1,000	< 5,000	< 5,000
Indeno(1,2,3cd)pyrene	< 50	< 1,000	< 5,000	< 5,000
Dibenzo(ah)anthracene	< 50	< 1,000	< 5,000	< 5,000
Benzo(ghi)perylene	< 50	< 1,000	14,000	(4,900)

As shown in Table 4-5, analysis for metals showed detectable levels of most constituents of concern in the untreated soil sample (M-S1). In addition, Table 4-6 summarizes noted quantities of barium, copper, lead, nickel, vanadium, and zinc in the leachate from WET analysis performed on the untreated soil.

Table 4-5 Untreated Soil, Metals Results (EPA Methods 6010/7471).

	B-S1	G-S1	P-S1	M-S1
	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Antimony	< 3.0	< 2.9	< 3.0	< 2.9
Arsenic	1.6	2.6	4.6	3.2
Barium	53	41	37	40
Beryllium	0.32	0.21	0.21	0.22
Cadmium	0.53	0.24	0.23	0.23
Chromium	30	20	16	18
Cobalt	4.3	3.0	3.2	3.1
Copper	8.1	24	98	60
Lead	5.4	14	180	90
Mercury	0.12	< 0.10	< 0.10	< 0.10
Molybdenum	< 0.99	< 0.98	< 0.99	< 0.98
Nickel	43	23	37	30
Selenium	0.33	0.30	0.74	0.44
Silver	< 0.5	< 0.49	< 0.50	< 0.49
Thallium	< 0.25	< 0.24	< 0.25	< 0.24
Vanadium	21	14	• 16	15
Zinc	22	19	36	26

Table 4-6 Untreated Soil, Metals-WET Results (EPA Methods 6010/7471).

	B-S1	G-S1	P-S1	M-S1
	(μg/L)	(μg/L)	(µg/L)	(µg/L)
Antimony	< 3,000	< 3,000	< 3,000	< 3,000
Arsenic	< 250	< 250	< 250	< 250
Barium	3,700	2,200	990	1,200
Beryllium	< 100	< 100	< 100	< 100
Cadmium	< 100	< 100	< 100	< 100
Chromium	< 500	< 500	610	< 500
Cobalt	< 1,000	< 1,000	< 1,000	< 1,000
Copper	< 500	2,500	7,100	5,100
Lead	290	1,000	14,000	6,700
Mercury	< 2.0	< 2.0	< 2.0	< 2.0
Molybdenum	< 1,000	< 1,000	< 1,000	< 1,000
Nickel	< 1,000	1,300	3,400	2,200
Selenium	< 250	< 250	< 250	< 250
Silver	< 250	< 250	< 250	< 250
Thallium	< 250	< 250	< 250	< 250
Vanadium	< 500	< 500	550	550
Zinc	< 1,000	1,200	3,800	2,500

The analysis results summarized in Table 4-7 show the untreated soil (M-S1) to have low pH corresponding to acidic conditions, as well as variable levels of chloride and sulfate. Whether the chloride and sulfate are associated with the oily phase, the water phase, or the soil found at Site 13 is unknown.

Table 4-7 Untreated Soil, pH/Chloride/Sulfate Results (EPA Methods 9045/325/375).

	B-S1	G-S1	P-S1	M-S1
pН	7.42	3.67	2.18	2.78
	B-S1 (mg/kg)	G-S1 (mg/kg)	P-S1 (mg/kg)	M-S1 (mg/kg)
Chloride	23	100	220	160
Sulfate	130	3,300	14,000	8,300

4.2 STEAM-TREATED SOIL

Treated soil samples were taken from each foot of the sand pack, with S1 taken from the top of the column and S4 from the bottom. All demonstrate a compositional change in the oily material after being subjected to steam flow. While there was little hydrocarbon mass removal during the SEE process, the TEH analysis shown in Table 4-8 illustrates a preferential removal of the kerosene fraction. Because of the analytical variability in the measurement of the higher molecular weight hydrocarbon fractions, the removal of those hydrocarbon fractions is more difficult to assess. However, the steam-treated soil data indicate that, in comparison to the untreated soil sample (M-S1), some diesel fraction and

no motor oil fraction has been removed by the steam process. Respective chromatograms for all the treated soils are shown in Figures 4-5 through 4-9.

Table 4-8 Steam-Treated Soil, TEH Results (EPA Method 8015).

	M-S1 (mg/kg)	S1-TOP (mg/kg)	S2 (mg/kg)	S3 (mg/kg)	S4-BOT (mg/kg)
Kerosene Range (C10-C12)	(13,000)	380	330	610	540
Diesel Range (C12-C22)	24,000	14,000	26,000	8,500	20,000
Motor Oil Range (C22-C50)	25,000	38,000	43,000	43,000	46,000

In comparison to the untreated soil sample (M-S1), chemical analysis performed on the treated soil samples showed non-detectable levels of BTEX constituents and an overall decrease in TVH as summarized in Table 4-9. In addition, TCLP analysis for BTEX constituents also demonstrated a decrease in BTEX constituents to non-detectable levels as given in Table 4-10.

Table 4-9 Steam-Treated Soil, BTEX/TVH Results (EPA Method 8020/8015).

	M-S1 (μg/kg)	S1-TOP (µg/kg)	S2 (μg/kg)	S3 (μg/kg)	S4-BOT (µg/kg)
Benzene	190	< 5	< 5	< 5	< 5
Toluene	840	< 5	< 5	< 5	< 5
Ethylbenzene	110	< 5	< 5	< 5	< 5
Xylene	930	< 5	< 5	< 5	< 5
Gasoline Range	9,600	< 1000	1, 600	< 1000	< 1000

Table 4-10 Steam-Treated Soil, BTEX-TCLP Results (EPA Method 8020).

	M-S1	S1-TOP	S2	S3	S4-BOT
	(μg/L)	_(µg/L)	(μg/L)	(μg/L)	(µg/L)
Benzene	18	< 0.5	< 0.5	< 0.5	< 0.5
Toluene	82	< 0.5	< 0.5	< 0.5	< 0.5
Ethylbenzene	11	< 0.5	< 0.5	< 0.5	< 0.5
Xylene	100	< 0.5	< 0.5	< 0.5	< 0.5

Analysis for PAH showed non-detectable levels for all constituents except for phenanthrene as shown in Table 4-11. However, it should be noted that the 7,500 ppb reporting limit for the treated soils was higher than that for the untreated soil (M-S1), which was only 5,000 ppb. Consistent with non-detectable TCLP PAH concentrations (<500 ppb) in the untreated soil, TCLP analysis for PAH constituents reported all quantities below the detectable limit of 100 ppb for all treated soil samples.

Table 4-11 Steam-Treated Soil, PAH Results (EPA Method 8270).

	M-S1	S1-TOP	S2	S3	S4-BOT
	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)	(µg/kg)
Naphthalene	(4,800)	< 7,500	< 7,500	< 7,500	< 7,500
Acenaphthylene	< 5,000	< 7,500	< 7,500	< 7,500	< 7,500
Acenaphthene	< 5,000	< 7,500	< 7,500	< 7,500	< 7,500
Fluorene	7,100	< 7,500	< 7,500	< 7,500	< 7,500
Phenanthrene	22,000	22,000	43,000	11,000	< 7,500
Anthracene	< 5,000	< 7,500	< 7,500	< 7,500	< 7,500
Fluoranthene	< 5,000	< 7,500	< 7,500	< 7,500	< 7,500
Pyrene	(4,100)	< 7,500	< 7,500	< 7,500	< 7,500
Benzo(a)anthracene	< 5,000	< 7,500	< 7,500	< 7,500	< 7,500
Chrysene	(4,900)	< 7,500	< 7,500	< 7,500	< 7,500
Benzo(b)fluoranthene	< 5,000	< 7,500	< 7,500	< 7,500	< 7,500
Benzo(k)fluoranthene	< 5,000	< 7,500	< 7,500	< 7,500	< 7,500
Benzo(a)pyrene	< 5,000	< 7,500	< 7,500	< 7,500	< 7,500
Indeno(1,2,3cd)pyrene	< 5,000	< 7,500	< 7,500	< 7,500	< 7,500
Dibenz(ah)anthracene	< 5,000	< 7,500	< 7,500	< 7,500	< 7,500
Benzo(ghi)perylene	(4,900)	< 7,500	< 7,500	< 7,500	< 7,500

As shown in Table 4-12, analysis for metals in the treated soil showed no significant change in metals concentrations except for a possible slight decrease in nickel and zinc. These results are consistent with the first treatability test. WET analysis performed on the treated soil samples showed an apparent reduction in the leachability of barium, copper, lead, nickel, vanadium and zinc as shown in Table 4-13.

Table 4-12 Steam-Treated Soil, Metals Results (EPA Methods 6010/7471).

	M-S1	S1-TOP	S2	S3	S4-BOT
	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Antimony	< 2.9	< 3.0	< 2.9	< 2.9	< 3.0
Arsenic	3.2	1.7	1.7	2.2	3.0
Barium	40	50	46	46	55
Beryllium	0.22	0.24	0.20	0.24	0.23
Cadmium	0.23	0.29	0.26	0.25	0.28
Chromium	18	20	19	19	17
Cobalt	3.1	2.1	2.3	2.1	2.3
Copper	60	70	65	63	51
Lead	90	110	100	110	160
Mercury	< 0.10	1	< 0.095	< 0.10	0.091
Molybdenum	< 0.98	< 0.99	< 0.98	< 0.96	< 1.0
Nickel	30	15	16	18	19
Selenium	0.44	0.39	0.34	0.49	< 0.25
Silver	< 0.49	< 0.50	< 0.49	< 0.48	< 0.50
Thallium	< 0.24	< 0.25	< 0.25	< 0.24	< 0.25
Vanadium	15	18	14	16	15
Zinc	26	17	12	17	18

Table 4-13 Steam-Treated Soil, Metals-WET Results (EPA Methods 6010/7471).

	M-S1	S1-TOP	S2	S3	S4-BOT
	(µg/L)	(μg/L)	(µg/L)	(µg/L)	(μg/L)
Antimony	< 3,000	< 3,000	< 3,000	< 3,000	< 3,000
Arsenic	< 250	< 250	< 250	< 250	< 250
Barium	1,200	< 500	< 500	< 500	< 500
Beryllium	< 100	< 100	< 100	< 100	< 100
Cadmium	< 100	< 100	< 100	< 100	< 100
Chromium	< 500	< 500	< 500	< 500	< 500
Cobalt	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000
Copper	5,100	< 500	< 500	< 500	< 500
Lead	6,700	590	590	1,900	1,100
Mercury	< 2.0	< 2.0	< 2.0	< 2.0	< 2.0
Molybdenum	< 1,000	< 1,000	< 1,000	< 1,000	< 1,000
Nickel	2,200	< 1,000	< 1,000	< 1,000	< 1,000
Selenium	< 250	< 250	< 250	< 250	< 250
Silver	< 250	< 250	< 250	< 250	< 250
Thallium	< 250	< 250	< 250	< 250	< 250
Vanadium	550	< 500	< 500	< 500	< 500
Zinc	2,500	< 1,000	< 1,000	< 1,000	< 1,000

The analysis results summarized in Table 4-14 show the treated soil samples at more near-neutral pH conditions than the untreated soil. The highest pH was detected in sample S1 located at the top of the soil column and therefore having the highest exposure to clean steam. In addition, the treated soil samples were also found to have lower concentrations of chloride and sulfate, with chloride apparently being removed by the steam more readily than the sulfate.

Table 4-14 Steam-Treated Soils, pH/Chloride/Sulfate Results (EPA Methods 9045/325/375).

	M-S1	S1-TOP	S2	S3	S4-BOT
pН	2.78	6.2	5.9	5.1	4.9

	M-S1	S1-TOP	S2	S3	S4-BOT	
	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	
Chloride	160	2.5	< 2.5	2.8	2.9	
Sulfate	8,300	660	1,100	4,100	1,000	

4.3 AQUEOUS EFFLUENT

Complementary to results from the treated soil analysis, TEH analysis performed on both the first and last effluent samples (1E and 10E, respectively) showed a preferential removal of the kerosene fraction. As seen in Table 4-15, the last effluent sample (10E) was found to contain more of the petroleum hydrocarbons in the diesel range than in the first effluent

sample. Due to a failure of equipment at Curtis and Tompkins, Ltd, the extracts of effluent samples 3E-9E were destroyed and, as such, TEH analysis was not performed. The chromatograms for both effluent samples are shown in Figures 4-10 and 4-11. During sampling, effluent sample 2E was compromised due to equipment failure and was therefore not sent for analysis

Table 4-15 Aqueous Effluent, TEH Results (EPA Method 8015).

	1E (mg/L)	10E (mg/L)
Kerosene Range (C10-C12)	429	2
Diesel Range (C12-C22)	858	1,200
Motor Oil Range (C22-C50)	11	3

The pre-leachability study sample showed a lower boiling fraction corresponding to the diesel/kerosene range and a higher boiling fraction that corresponded to the motor oil fraction. The presence of the higher boiling point fraction is considered an anomaly and, thus, leachability study results are not reported.

As shown in Table 4-16, chemical analysis performed on the effluent samples showed the initial presence and then non-detectable levels of BTEX constituents. Data show that the major mass of benzene was removed in the first effluent sample (1E) with toluene, ethylbenzene and then xylene being present in later effluent samples. This observation is in accord with the vapor pressures of these constituents, with low boiling point benzene being removed preferentially. An overall decrease in TVH over the period of steam injection was also observed.

Table 4-16 Aqueous Effluent, BTEX/TVH Results (EPA Methods 8020/8015).

	1E	3E	4E	5E	6E	7E	8E	9E	10E
	(µg/L)	(μg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
Benzene	3,300	< 200	< 130	< 50	< 500	< 500	< 250	28	< 500
Toluene	35,000	1,000	620	88	2,900	1,200	< 250	61	< 500
Ethylbenzene	5,100	1,000	< 130	89	3,000	1,400	< 250	43	< 500
Xylene	42,000	6,800	950	510	16,000	5,500	< 250	249	< 500
Gasoline Range	260,000	680,000	82,000	68,000	650,000	380,000	46,000	94,000	62,000

In Table 4-16, Samples 6E and 7E both showed higher BTEX and TVH values possibly since the steam flow rate during these sampling periods was twice that injected for other sampling times. While the steam flow rate itself would not have the effect of increasing the concentrations, the resulting higher pressures at the beginning of a depressurization cycle may cause an apparent increase in evaporation rates if those rates were mass transfer limited.

PAH analysis of the effluent samples were inconclusive due to different dilution ratios and thus highly variable detection limits as shown in Table 4-17.

Table4-17 Aqueous Effluent, PAH Results (EPA Method 8270).

	1E	3E	4E	5E	6E	7E	8E	9E	10E
	(µg/L)	(µg/L)	(µg/L)	(μg/L)	(µg/L)	(µg/L)	(µg/L)	(μg/L)	(µg/L)
Naphthalene	(2,500)	<44,000	<22,000	<8,000	<4,400	<13,000	<200	(140)	350
Acenaphthylene	<4,300	<44,000	<22,000	<8,000	<4,400	<13,000	<200	<200	<200
Acenaphthene	<4,300	<44,000	<22,000	<8,000	<4,400	<13,000	<200	<200	<200
Fluorene	<4,300	<44,000	<22,000	<8,000	<4,400	<13,000	(120)	(130)	600
Phenanthrene	<4,300	<44,000	<22,000	(6,000)	4,900	(8,800)	2,200	5,100	4,800
Anthracene	<4,300	<44,000	<22,000	<8,000	<4,400	<13,000	<200	(180)	<200
Fluoranthene	<4,300	<44,000	<22,000	<8,000	<4,400	<13,000	(160)	(170)	<200
Pyrene	<4,300	<44,000	<22,000	<8,000	<4,400	<13,000	280	260	410

The pH, chloride, and sulfate analytical data for the effluent samples summarized in Table 4-18 show a dramatic increase in pH to near-neutral conditions and an overall decrease in chloride and sulfate concentrations after the first sample. It is not known why the sulfate concentrations in 5E and 8E were high relative the effluent stream after the first sample. However, the large variations between the concentrations of the non-volatile components in first effluent sample and the subsequent samples is evidence that the steam is effectively displacing the pore water and associated aqueous phase constituents during the initial stages of steam injection.

Table 4-18 Aqueous Effluent, pH/Chloride/Sulfate Results (EPA Methods 9040/325/375).

	1E	3E	4E	5E	6E	7E	8E	9E	10E
pН	2.5	4.1	4.6	4.1	4.6	4.2	3.8	4.9	4.7
	1E (mg/L)	3E (mg/L)	4E (mg/L)	5E (mg/L)	6E (mg/L)	7E (mg/L)	8E (mg/L)	9E (mg/L)	10E (mg/L)
Chloride	850	40	7.9	14	2.0	3.5	16	1.7	3.2
Sulfate	24,000	13	28	2,100	90	28	1,600	66	52

5. CONCLUSIONS

While chemical analyses from this experiment showed that the total hydrocarbon mass removal was relatively small, SEE effectively removed the lighter hydrocarbon fractions including benzene, toluene, ethylbenzene, and xylene. As such, only the less mobile, higher molecular weight fractions remained as residuals. In addition, analyses showed an apparent reduction in the leachability of some metal constituents as well as the ability of SEE to restore pore water to near-neutral pH conditions.

6. QUALITY ASSURANCE/QUALITY CONTROL

6.1 LABORATORY PROCEDURES

This one-dimensional laboratory treatability study followed the quality assurance and quality control (QA/QC) procedures outlined in the Contractor Quality Control Plan. In addition, all water used during steam injection was first distilled and then boiled to reduce the amount of dissolved gases. All tubing used to carry water and effluent was of polytetrafluoroethylene (PTFE) to lower the risk of water or effluent contamination by interaction with the tubing material. In order to minimize the chance of system contamination throughout the experiment, the system remained closed except for the necessary supply of water to the metering pumps and sample bottle changing.

All sample bottles were prepared by washing with nonphosphate detergent followed by multiple tap and distilled water rinses. After washing, the bottles were oven dried and sealed with Teflon caps prior to use. While sampling for effluent, bottles were kept in an ice bath to keep the effluent temperature low and minimize potential evaporation. All full sample bottles were capped with a Teflon cap and placed in a refrigerator or cooler containing ice to maintain temperatures at $4 \, ^{\circ}\text{C}$ ($\pm 2 \, ^{\circ}\text{C}$).

After sampling was completed, all soil and effluent samples were packed in coolers with foam and ice. A method blank filled with distilled water as used in the metering pumps was also placed in each cooler along with the first sample. As such, the method blank should have indicated any cross-contamination in the sample preparation, storage and transportation. Coolers were sealed with custody tape and sent along with a chain of custody form within the prescribed holding times.

6.2 CHEMICAL ANALYSIS

Analyses of various samples showed variable and often high reporting limits for specific analytes compared to those usually encountered in many soil or waters samples. The high reporting limits are due to sample dilutions made in attempts to decrease the chromatographic background present due to the complex nature of the hydrocarbon mixtures. Attempts to remove the background interferences by cleanup procedures were somewhat successful, but reporting limits were still elevated for most samples. This information will be used for planning and conducting future analysis when specific reporting limits are required.

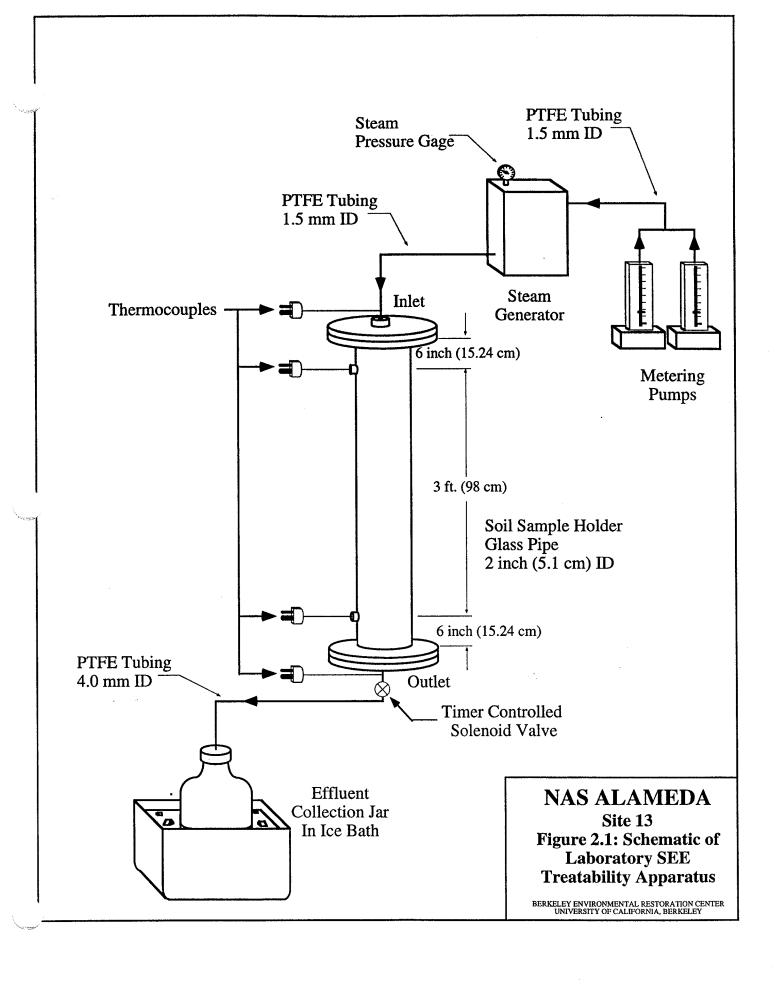
As a check for mass balance of BTEX constituents, the analysis data for BTEX constituents in soil sample MS-1 were compared to those for TCLP extracts on the untreated soil. This mass balance approach found that the mass of individual BTEX constituents in the soil sample (Table 4-2) constituted approximately half of the mass found in the TCLP extracts (Table 4-3); the comparison was made on the basis that the TCLP procedure used 25 grams of soil MS-1 extracted with 500 mL of solution. Discussions with the Curtis and Tompkins' laboratory supervisor indicated that the BTEX constituents reported for soil sample MS-1 were likely to be low due to an incomplete purging of the BTEX constituents from the oily matrix during the standard (11 minute) purging time. This effect will be considered in planning future BTEX and TVH analyses, and suggest that the SEE process was even more effective at removing BTEX than would be expected from the data obtained using standard analyses of soils.

Extractable amounts of PAHs were generally found to be non-detectable by the TCLP method. This result is attributable to the low water solubilities of PAHs and their high

sorption coefficients for soil/water and oil/water partitioning. Calculations for soil/water and oil/water partitioning of phenanthrene support the observation that concentrations below reporting limits would be expected. Thus, the absence of PAHs in the extracted solutions is explained, and PAHs would not be expected to leach from either untreated or steam-treated soils.

The data obtained in this treatability study are considered suitable for use in evaluating the effectiveness of SEE. With a few exceptions, most samples were analyzed within sample holding time limits and showed acceptable surrogate recoveries. The exceptions and their significance are briefly discussed below:

- a) The laboratory analysis for motor oil and Bunker C oil in the steam-treated soils were initially reported as being in excess of one million parts per million (ppm). Although outside of the stated holding time, the laboratory re-ran the samples along with a sample of the untreated soil. The re-analysis of the untreated soil was found to be in agreement with initial analysis of the same soil sample. The treated soils were found to give lower concentration than the initial analysis, and with concentrations comparable to the analysis of the untreated soil sample (Table 4-1). The respective chromatograms of the two sets of treated soils are qualitatively similar, and the laboratory could not explain the higher concentration values initially reported. The similar concentrations of the fractions corresponding to diesel and motor oil in the treated and untreated soils samples is consistent with other data obtained in the treatability study and are considered useful for project purposes even though holding times were exceeded.
- b) The holding time for pH analysis of effluents was specified as 24 hours. However, it was necessary to hold some samples over the weekend before delivery to the laboratory for analysis. As such, sample 1E was analyzed for pH on Friday and then again on the Monday following the weekend in order to demonstrate that pH remained constant over that time period. As the data for the two sampling events were consistent, effluent samples taken during the weekend were refrigerated and held for delivery until the following Monday.



APPENDIX D CONTRACTOR QUALITY CONTROL PLAN

PILOT-SCALE TREATABILITY WORK PLAN STEAM ENHANCED EXTRACTION SITE 13 NAVAL AIR STATION ALAMEDA ALAMEDA, CALIFORNIA

APPENDIX D CONTRACTOR QUALITY CONTROL PLAN

Contract Number: N62474-94-D-7430 Delivery Order No. 003

Submitted to:

EFA WEST (Code 0222)
Naval Facilities Engineering Command
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San Bruno, CA 94066-5006

Submitted by:

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PILOT-SCALE TREATABILITY WORK PLAN STEAM ENHANCED EXTRACTION SITE 13 NAVAL AIR STATION ALAMEDA ALAMEDA, CALIFORNIA

APPENDIX D CONTRACTOR QUALITY CONTROL PLAN

Revision 1

UNCLASSIFIED March 20, 1996

Approved by:	Date:	3/20/96
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APPENDIX D

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1. INTRODUCTION

This Contractor Quality Control Plan (CQCP) provides quality assurance/quality control (QA/QC) procedures to be followed for the three-well treatability test being completed as part of the pilot-scale treatability study of Steam Enhanced Extraction (SEE) at Site 13, Naval Air Station (NAS) Alameda. Site 13 is an abandoned oil refinery with oily waste identified in the soil below the four foot deep water table. The design, implementation, and operation of the three-well treatability test is described in the *Pilot-Scale Treatability Study Work Plan* (Work Plan). The Work Plan also provides background information on NAS Alameda and Site 13.

The Contractor Quality Control Program Plan (CQCPP) describes general QA/QC procedures to be followed for the partnership agreement between the University of California at Berkeley (UCB) and the U.S. Navy. Standard procedures to be followed for the project are described in the Standard Quality Procedures (SQPs) and the Standard Operating Procedures (SOPs); specific SOPs and SQPs are referenced herein as appropriate.

2. ORGANIZATION

The three-well treatability test is being implemented under a partnership agreement (Government Contract No. N62474-94-D-7430) between UCB and the U.S. Navy. This agreement provides a framework for exploring the application of innovative environmental restoration technologies developed by UCB, Lawrence Livermore National Laboratory (LLNL), and Lawrence Berkeley National Laboratory (LBNL) at NAS Alameda. As part of the partnership agreement, UCB established the Berkeley Environmental Restoration Center (BERC) as a coordination office to administer the contract for UCB. For the three-well treatability test, UCB will manage the project; Dr. Kent Udell is the Principal Investigator. LLNL is providing Cross-hole Electrical Tomography to help track propagation of the steam front.

An organization chart for the BERC program staff supporting the three-well treatability test, including program level positions, is provided on Figure 2-1. The job responsibilities for each position identified on the organization chart are described in Section 2 of the CQCPP. A project specific organization chart is provided on Figure 2-2, including activities that will be subcontracted. Specific personnel and subcontractors to be assigned to each position will be identified in a separate project management submittal to the U.S. Navy including documentation of the training and qualifications for personnel assigned to each position. This project management submittal will be periodically updated as there are changes in personnel.

3. QUALITY CONTROL MANAGEMENT

This CQCP provides the procedures, practices, and objectives for meeting the quality objectives for the three-well treatability test. Appropriate sections of the CQCPP and Work Plan are referenced as appropriate, rather than repeating sections from these documents. Appropriate SOPs and SQPs are also referenced.

The CQCPP and CQCP are controlled documents and will be controlled in accordance with Section 6.0 of the CQCPP, SQP 4-1, *Document Control*, and 4-2, *Records Management*.

The Contractor Quality Control Manager (CQCM) will be responsible for implementing the CQCP during implementation of the three-well treatability test, in accordance with the requirements of

Contract No. N62474-94-D-7430 and Delivery Order No. 0003. The letter appointing the CQCM, stating authority and appropriately signed, will be included with the separate project management submittal to the Navy. A copy of the CQCP will be maintained at Site 13, in the BERC offices, and in any subcontractor offices throughout all field activities.

3.1 Project Planning

The primary objective of the pilot-scale treatability study is to provide sufficient data to evaluate the effectiveness of the SEE process in reducing waste oil concentrations in the soil and groundwater at Site 13. To accomplish this objective, the pilot-scale treatability study will be implemented in two phases. The first phase will be the three-well treatability test and the second phase will be the 15-well pilot-scale test. Proper project planning is essential to ensuring that all project tasks are completed in a timely manner and are adequate for the required scope of work. The Work Plan and this CQCP describe the procedures to be followed for the three-well treatability test. A separate work plan and CQCP will be prepared for the 15-well pilot-scale test if the decision is made to proceed to this second phase of the pilot scale treatability study. Health and safety procedures to be followed for the three-well treatability test are described in the Site Health and Safety Plan (Appendix H to the Work Plan).

3.2 QUALITY CONTROL MEETINGS

The CQCM will ensure that the following meetings are conducted in accordance with the requirements of Section 3.0 of the CQCPP:

- A coordination and mutual understanding meeting, held prior to the start of construction.
- Quality control meetings, held once every two weeks at the work site following the start up of construction. The CQCM will submit meeting notes to the U.S. Navy within two working days of each meeting.

4. PERSONNEL TRAINING AND QUALIFICATION

The qualifications of personnel assigned to the project will be evaluated by the CQCM and documented on the Personnel Qualification Evaluation and Verification form (Figure 4-1) in accordance with SQP 3.2, *Indoctrination and Training*. This documentation will be provided in the separate project management submittal to the U.S. Navy as specified in Section 2, above.

Project personnel will be indoctrinated/trained to the following documents, as appropriate:

- Contractor Quality Control Program Plan
- Health and Safety Plan, Volumes I and II
- Site Health and Safety Plan
- Contractor Quality Control Plan
- Standard Operating Procedures as applicable
- Standard Quality Procedures as applicable

Delivery order objectives and goals

This and other project specific training will be documented on the Training Attendance Record form (Figure 4-2) and provided in the separate project management submittal. Any additional training received will also be documented on this form.

5. INSTRUCTIONS, PROCEDURES, AND DRAWINGS

UCB and the CQCM will review design documents prepared by subcontractors in accordance with the requirements of Section 5.1 of the CQCPP. When a conflict with the design documents arises during implementation of the treatability study, UCB will immediately notify the U.S. Navy of the conflict in writing or through the use of a Field Work Variance (FWV) request, Figure 5-1. Recommended solutions to resolve the conflict will be included. As built drawings for any construction will be prepared and maintained in accordance with Section 5.3 of the CQCPP.

SQPs and SOPs are developed to provide instructions for quality related activities for the three-well treatability test. A listing of applicable SQPs and SOPs is provided in Table 4-1. The methods and associated responsibilities for the development, control, and implementation of SQPs are described in SQP 5.1, *Preparation, Revision, and Approval of Plans and Procedures*. Distribution will be in accordance with SQP 4.1, *Document Control*.

6. DOCUMENT CONTROL AND RECORDS MANAGEMENT

Documents that prescribe activities affecting quality of the three-well treatability test, such as work plans, procedures, instructions, and drawings, are prepared and issued as controlled documents to ensure that correct and applicable versions are available at the work location. Methods for control and issuance of controlled documents are specified in SQP 4.1, *Document Control*. Controlled documents for this activity include the following:

- Delivery Order 003
- the CQCPP
- the Work Plan with accompanying CQCP and HSP
- Standard Operating Procedures
- Standard Quality Procedures
- Design Drawings and Specifications

Design drawings and specifications are distributed with a document transmittal form, Figure 6-1, Transmittal of Shop Drawings, Equipment Data, Material Samples, or Manufacturers Certificates of Compliance.

The controlled documents are prepared by project level staff and are reviewed and ultimately approved and signed by the Program Manager, Contractor Quality Control Program Manager, Project Manager (PM), and the CQCM. They are issued to project personnel who require them to complete their job function with the Document Receipt Acknowledgment Form (Figure 6-2).

A document control log is maintained by the CQCM which includes the document title, control number, current revision status, and name of assignee. Once a document is revised, the CQCM compiles outdated versions of each report document and distributes the revised document to appropriate personnel. Receipt of outdated documents is recorded on the document control log.

Submittals that will be required for the Pilot-Scale Treatability Study are identified on the Submittal Register, Eng Form 4288 which is provided in Figure 6-3. The PM is responsible for ensuring that these documents are completed. The CQCM tracks the status of receipt of comments and revisions of each submittal and all resubmittals are noted on the Submittal Register using the same number as the original submittal followed by a sequential alphanumeric suffix. Any submittals prepared by subcontractors and vendors are reviewed and accepted by the PM and the CQCM prior to submittal to UCB by the CQCM.

The CQCM also prepares a Daily Quality Control Report (DQCR) (Figure 6-4) for each day that field work is performed and once monthly when field work is not being performed. DQCRs will be submitted weekly when all field operations are manual, for example in hand augering. DQCRs will be submitted weekly when all field operations are manual (i.e., hand augering).

In accordance with the requirements of Section 6.9 of the CQCPP, the PM or Site Superintendent prepares a Daily Contractor Production Report (DCPR) (Figure 6-5) for each day the field work is performed. Completion of the DCPR is not required for periods when there is no field work. The field activity daily log (Figure 6-6) is prepared for each day of field work.

7. PROCUREMENT

Procurement documents will be prepared and reviewed in accordance with the requirements of Section 7 of the CQCPP to ensure that technical and quality requirements are included or specified by reference. Procurement document review will be performed in accordance with SQP 6.1, Preparation, Review, and Approval of Procurement Documents.

8. DATA QUALITY OBJECTIVES

U.S. EPA guidance for obtaining quality date is discussed in Section 8.3.3 of the CQCPP. Previous U.S. EPA guidance identified several levels of data quality that corresponded to anticipated data usage (screening, litigation, etc.) More recent guidance has replaced these levels by using a seven step DQO process that describes how the data will be applied to resolving specific site issues, and which then drive decisions regarding accuracy, precision, representatives, comparability, and completeness of the data collection process. The DQO process is then focused on providing sufficient and well defined data for a specific use, which is more definitive than what the previous "data quality level" structure could provide. The seven step DQO process is based primarily on obtaining data for use in risk assessments and remediation decision making, but generally applied to all data collection activities.

This DQO process has been applied to the three-well treatability test as outlined in Table 8-1. Some aspects of the collection of samples and design of the treatability system are discussed in the Work Plan and the Sampling and Analysis Plan for the Three-Well Treatability Test (Appendix F), or in the SOPs. In the review of the DQOs for this test, it must be recognized that the data will not be directly used in risk or remediation decision making, but rather to establish the applicability of using the data obtained to assess the performance of SEE at Site 13.

9. FIELD ACTIVITIES

Field activities that will be performed for the three-well treatability test are described in the Sampling and Analysis Plan for the Three-Well Treatability Test (Appendix F of the Work Plan). These activities include:

- Utility clearance;
- Cone penetrometry testing with 1) analyses by laser-induced fluorescence for further characterization of the extent of refinery wastes in the soil and 2) soil sample analyses to establish baseline chemical concentrations;
- A survey of the site to determine ground elevations and reference existing wells and prior soil borings;
- Site grading for appropriate drainage from surface containment system;
- Installation and development of injection/extraction wells, with associated soil and groundwater sampling and water level measurements;
- Hydraulic testing of the injection/extraction wells;
- Installation of groundwater monitoring wells with associated soil and groundwater sampling and water level measurements;
- Installation of temperature observation wells;
- Installation of the electrode wells;
- A survey of the graded site and new well locations;
- Installation of surface containment systems;
- System operation;
- Post demonstration sampling; and
- Waste sampling (soil, water, free phase hydrocarbons).

To ensure the representativeness of all samples collected, the sampling methods specified in the Sampling and Analysis Plan for the Three-Well Treatability Test, Appendix F of the Work Plan and in the referenced SOPs and SQPs will be followed. The number of soil and groundwater samples to be collected and analyses to be performed during the three-well treatability test are summarized in Tables 1-1, 1-2, 1-4, 2-1, 2-2, 8-1, and 9-1 of the Sampling and Analysis Plan for the Three-Well Treatability Test, Appendix F of the Work Plan.

9.1 SITE WALK AND PERMITTING

Before initiation of field activities, the PM and Site Superintendent will review all appropriate information (maps, plans and drawings) to identify potential buried, surface, or overhead hazards at the site. Site access and security requirements will also be determined as required. The PM and Site Superintendent will also conduct a site walk to:

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- Evaluate site safety considerations (utility locations, health and safety concerns);
- Identify boring and well locations and available access;
- Identify the locations of areas to store equipment to be used during the project;
- Identify the location of areas to be used to store drill cuttings, water and other wastes pending disposal; and
- Discuss the field activity sequence and schedule as they relate to security needs, NAS Alameda operations, project operations, and subcontractor access requirements.

9.1.1 Permitting Considerations

Federal and State Regulatory agencies are following CERCLA guidance to manage the Installation Restoration Program at NAS Alameda. Therefore, the U.S. Navy, as the lead agency, will comply with the substantive requirements of Federal and State permits, but will not actually obtain the permits. The U.S. Navy will obtain those permits required by local agencies.

Federal and State requirements cover the injection of steam into the subsurface, the construction and operation of the thermal oxidizer, the discharge of gasses from the carbon treatment units, and the discharge of water from the carbon treatment units. The Federal Safe Drinking Water Act contains requirements for the Underground Injection Control Program, which assigns wells used in experimental technologies to Class V. Criteria and standards applicable to Class V injection wells can be found in 40 CFR Part 146, Subpart F.

The steam injection wells are expected to comply with the requirements for Class V wells, as underground injection of the steam is not expected to result in any of the following: movement of a fluid containing any contaminant into underground sources of drinking water, contamination causing a violation of the primary drinking water standards or degradation of groundwater guality, or a contaminant adversely affecting human health. Groundwater monitoring wells installed near the injection wells will verify that contaminants will be contained within the steam injection zone.

To comply with the substantive requirements of regulations issued by the State of California's Bay Area Air Quality Management District, the thermal oxidizer and gas phase carbon treatment units will be designed and constructed to emit less than 1 pound per day of total volatile hydrocarbons and 0.05 pounds per day of benzene. A field monitoring instrument, either a photoionization detector or a flame ionization detector, will be used to estimate the rate of volatile emissions from the thermal oxidizer. Emission rates will be measured daily for the first week of operation, then weekly, and then less frequently, but at least once each month. Permission to operate the thermal oxidizer will be obtained from the NAS Alameda Fire Department.

To comply with the substantive requirements of the Clean Water Act, treated water discharged from the liquid phase carbon units will be discharged to the NAS Alameda wastewater collection system under a permit from the East Bay Municipal Utility District. Discharge limitations will be established when the permit is granted. Initially, the treated water will be held in a tank and tested for compliance with the permit conditions before discharge. After one week of compliant operation, the water may be continuously discharged and monitored, initially every week, then less frequently, but at least once each month, for compliance with permit assistance requirements.

Soil boring and groundwater monitoring well permits will be obtained from the Alameda County Zone 7 Flood Control Agency in accordance with the requirements of Alameda County Ordinance Number 73-68. The Flood Control Agency does not have specific requirements for the underground injection of steam.

9.2 FIELD EQUIPMENT, CONTAINERS, AND SUPPLIES

Several different pieces of equipment and field supplies will be used to support the three-well treatability test. Required equipment and supplies include but are not limited to:

- Heavy equipment for grading the site;
- Drilling rigs (Geoprobe, auger, and reverse circulation) and a CPT rig;
- Well development rig;
- Soil sampling equipment split spoon;
- Groundwater sampling equipment pumps;
- Water quality meters pH, specific conductance, temperature;
- Water level and product thickness meter;
- Sampling containers brass sleeves and groundwater sample containers;
- Temperature monitoring well installation rig;
- Electrode strands;
- Well construction materials;
- Field screening equipment photoionization detector;
- Decontamination supplies;
- Waste storage containers baker tanks, drums, roll off boxes;
- Personal protective equipment; and
- Containment, conveyance, and treatment system components;

The equipment selected for use during the three-well treatability test will be constructed of materials that will not react with chemicals identified in the materials identified in the soil and groundwater and will not contaminate samples collected through its use. Unless otherwise specified, sample containers used will be precleaned according to EPA protocols. In order to minimize the decontamination of sampling equipment, sampling equipment made of disposable materials may be used, where permitted, and discarded following its use.

9.3 FIELD QUALITY CONTROL SAMPLES

The field quality control samples to be collected during the project include trip blanks, equipment rinseate samples, field blanks, and field duplicates as described in Section 11 of the Sampling and

Analysis Plan for the Three-Well Treatability Test, Appendix F of the Work Plan. The methods for preparation of these samples are described in SOP 18.1. A description of each type of QA/QC samples is as follows:

- Trip blanks consist of two volatile organic analysis (VOA) vials filled with ASTM Type 2 water. These vials are prepared by the laboratory, travel to field site, and are returned to the laboratory for storage and analysis along with the field samples. Trip blanks will be analyzed for BTEX. One trip blank will be prepared for each cooler of soil or groundwater samples to be analyzed for BTEX;
- Rinseate blanks consist of ASTM Type 2 reagent water collected from a final rinse of sampling equipment after decontamination procedures have been performed. A minimum of one equipment rinsate sample per week will be prepared. Rinseate samples collected during soil sampling will be collected from the final rinseate form the soil sampling equipment. Rinseate from groundwater sampling will be collected from the bailer by pouring ASTM Type 2 deionized water into the bailer and then into the appropriate sample container;
- Field blanks consist of water from each source of decontamination water used during each sampling event. The water will be poured directly into the appropriate sampling containers and the sample will be analyzed for the same parameters as the soil or groundwater samples being analyzed; and
- Field duplicates provide data to access the precision of the sampling methods. Field duplicates of groundwater samples will be analyzed for the same parameters as the groundwater samples. Field duplicates will be collected at a rate of 10% of the groundwater samples. No duplicate soil samples will be collected.

The expected number of QA/QC samples and analyses to be performed during each field phase of the three-well treatability test are summarized in Tables 1-2, 2-1, 2-2, 8-1 and 9-1 of the Sampling and Analysis Plan for the Three-well treatability test, Appendix F of the Work Plan; the estimated number of QA/QC samples is based on the expected duration of field activities. However, the number of QA/QC samples to be analyzed will be dependent on many factors and may change. The number of trip blanks to be analyzed will be dependent on the duration of sampling and the number of shipments to the laboratory. The number of rinseate blanks will be dependent on the duration of sampling. The number of field blanks to be analyzed will be dependent on how many sources of decontamination fluids are used. Regardless of these variables, each type of QA/QC sample will be collected according to the minimum frequencies identified above.

9.4 SAMPLE COLLECTION, PRESERVATION, AND HOLDING TIMES

Samples to be collected during the pilot-scale treatability study include subsurface soil samples, groundwater samples, and liquid and gaseous influent and effluent samples. Collection of these samples are described in the Sampling and Analysis Plan for the Three-Well Treatability Test, Appendix F of the Work Plan. The required containers, preservation methods and holding times for each analysis are specified in Table 14-1 of the Sampling and Analysis Plan for the Three-Well Treatability Test.

9.5 SAMPLE COLLECTION LOG

A Sample Collection Log (Figure 9-1) will be filled out for each sample collected. The sample collection log includes the following information:

- collection date and time;
- project number;
- project name;
- unique sample number;
- sample location and type;
- container type and preservative;
- compositing information;
- depth of sample;
- weather;
- field observations;
- problems encountered; and
- name of sample collector.

The sample collection logs are given to the CQCM to be filed in the project files sequentially by field sample number.

9.6 SAMPLE CUSTODY AND DOCUMENTATION PROCEDURES

9.6.1 Chain of Custody/Request for Analysis

Throughout field sampling activities, proper chain of custody procedures will be followed to demonstrate that samples were obtained from the locations stated and that they reached the laboratory without alteration. Documentation of compliance will be accomplished by using the Chain of Custody Record (COC) provided in Figure 9-2. This form also provides a formal request for sample analysis. Chain-of-custody procedures will be implemented in accordance with SOP 1.1 and as described in Section 9.6.1 of the CQCPP. Copies of completed COCs will be provided to the CQCM to be filed in the project files by serial number.

9.6.2 Sample Handling and Shipping

The handling and shipment of samples to the laboratory are performed according to the Department of Transportation (DOT) regulations, SOP 2.1, and Section 9.6.3 of the CQCPP. This should prevent damage, loss, or unacceptable deterioration is prevented. The International Air Transportation Association (IATA) regulations are adhered to when shipping samples using air courier services. Transportation methods are selected to ensure that samples arrive at the laboratory in time to permit testing in accordance with established holding times and project schedules.

10. ANALYTICAL ACTIVITIES

Any laboratory performing analytical laboratory services for the pilot-scale treatability study will be certified by the Facilities Engineering Service Center (NFESC) and the California Environmental Protection Agency for the laboratory analytical methods required; documentation of certification will be submitted to the U.S. Navy for approval. Sample documentation will be verified at the laboratory, and samples received will be checked and logged into the Laboratory Information Management System (LIMS) database according to the procedures described in Section 10.1 of the CQCPP. Methods for preanalysis and post analysis storage are specified in Sections 10.2 and 10.3 of the CQCPP.

Analytical methods to be utilized for the pilot-scale treatability study are specified in Table 1-3 of the Sampling and Analysis Plan for the Three-Well Treatability Test, Appendix F of the Work Plan. Laboratory procedures to be followed are addressed in Section 10.4 of the CQCPP and required detection limits are specified in Table 10-1 of the CQCPP. Analyses performed for the laboratory treatability tests have shown that in some cases these detection units are not achievable because of matrix interferences. For all samples analyzed the lowest achievable detection limit, depending on sample interference will be maintained. To maintain quality control, the laboratory maintains written SOPs as specified in Section 10.5 of the CQCPP and the requirements of the CQCPP are followed for analytical standards, method quality control, and the analysis of laboratory quality control samples (Sections 10.6, 10.7 and 10.8 of the CQCPP).

In accordance with the requirements of Section 10.9.1 of the CQCPP, the laboratory will reduce the analytical data using procedures provided in E.P.A. document SW-846. The data will be verified by the laboratory and the Project Chemist according to the requirements of Section 10.92 of the CQCPP.

The laboratory will report all laboratory results on Standard Laboratory Reports discussed in Section 10.9.3.3 of the CQCPP. The laboratory data reports will include the following at a minimum:

- A case narrative;
- Copies of nonconformance/corrective action forms;
- Copies of COC forms;
- Copies of sample receipt notices;
- Analytical results for all samples included on the COC, including documentation of dilutions and reanalyses and the laboratory detection limits used; and
- Analytical results for all required laboratory quality control samples specified in Section 10 of the CQCPP.

Independent of the laboratory review, the Project Chemist performs data validation as required by Section 10.10 of the CQCPP. The procedures to be used for data validation are contained in the US EPA Contract Laboratory Program National Functional Guidelines for Organic Data Review (1994) and the US EPA Contract Laboratory Program National Function Guidelines for Inorganic Data Review (1994). For parameters that are not included in these guidelines, evaluation is performed following HAZWRAP in DOE/HWP-65/RI. Following the data validation, the sample data will be submitted to the CQCM for distribution to the appropriate personnel.

If a problem occurs which requires corrective action, the responsible laboratory personnel will complete a nonconformance report as specified in Section 16 of this CQCP. The nonconformance report will be submitted to the laboratory PM who will contact the Project Chemist for resolution. The nonconformance reports are copied to the Project Chemist and CQCM for "rework" or "report as is" situations.

11. REPORT PREPARATION

The reports required for the three-well treatability test include (1) this Pilot Scale Treatability Study Work Plan and (2) a letter report summarizing the results of the three-well treatability test and making recommendations for continuation of the pilot-scale treatability study. For each report, the PM will ensure that the appropriate format is identified and the appropriate personnel are assigned to prepare the report as specified in Section 11.0 of the CQCPP. The generalized report format is specified in Section 11.1 of the CQCPP. The letter report may follow a different format.

A total of 12 copies of the draft and final Work Plan will be submitted to the Navy for review by the Navy, BRAC Cleanup Team, contractors, and RAB members. The Work Plan will be accompanied by a submittal transmittal letter which states the report title, number of copies transmitted, and the UCB personnel to contact regarding questions concerning the report. The transmittal letter will be signed by the PI, indicating approval for release.

The Navy will provide comments on the draft Work Plan within 30 calendar days after receipt. UCB will provide a final Work Plan with a response to comments received within 14 to 21 calendar days of receipt of comments. The Navy will provide approval of the final Work Plan within seven days of receipt.

The letter report will not be subject to this review and revision process. It will be issued as final at the first release.

12. REVIEW OF WORK ACTIVITIES

12.1 TECHNICAL REVIEWS

The Program Manager will ensure that plans, procedures, and reports receive technical review to ensure technical quality. The Project Manager may conduct the technical review or select qualified reviewers from within UCB or UCB Subcontractors. The requirements for the technical review are identified in Section 12.1 of the CQCPP. The review status of each submittal is tracked on the Manuscript Routing Form (Figure 12-1).

12.2 PEER REVIEWS

The Project Manager will ensure that a peer review is also performed for documents regarding highly complex technical subjects or for areas of the project where technical criteria and requirements do not exist for the work performed. This peer review provides evaluation and assessment of interpretations, judgments, and decisions made where established technical criteria do not exist. Peer reviews are further described in Section 12.2 of the CQCPP.

In general, review of design documents will be performed by a qualified Professional Engineer (P.E.), sampling data or groundwater data will be reviewed by a Registered Geologist (R.G.) or

hydrogeologist.

12.3 REVIEW OF DOCUMENTATION

When the Project Manager and the author determine that a document is ready for technical or peer review, the Project Manager will select the appropriate technical or peer reviewer. The review will be documented according to the methods specified in Section 12.3 of the CQCPP.

13. INSPECTIONS

During construction and operation of the three-well treatability test, the CQCM will schedule inspections for each definable feature of work identified in Figure 13.1. These definable features of work are identified on the basis of the tasks described in the Work Plan and appropriate sections of the Work Plan are referenced. Upon completion of design documents for the three-well treatability test, the definable features of work will be reviewed and each feature will be referenced to a specification number. Revisions to the definable features of work will be made as appropriate.

For each definable feature of work, inspections will be made during the preparatory phase, initial phase, and follow-up phase. These phases and inspection requirements for each phase are described in Sections 13.4, 13.5, and 13.6 of the CQCPP. The CQCM, Site Superintendent, applicable foreman, and subcontractors involved in the activity attend each inspection. The results of the inspection are documented on the inspection reports included as Figures 13-2, 13-3, and 13-4. These reports are included as an attachment to the Daily QC Report submitted to the U.S. Navy. Off-site inspections may also be conducted to inspect the place of fabrication for equipment that is manufactured off-site

The CQCM will perform each inspection or assign a qualified individual; personnel will not perform inspections of their own work. The Resident Officer in Charge of Construction shall be notified 48 hours in advance of all planned inspection activity to coordinate their participation.

Upon completion of the scope of work identified in the delivery order, The CQCM will furnish a certificate attesting that the work has been completed, inspected, and tested, and is in compliance with the requirements of the delivery order.

14. CALIBRATION AND MAINTENANCE OF MEASURING AND TEST EQUIPMENT

Anticipated laboratory and field measuring and test equipment (M&TE) that will require calibration include:

- Water quality meters pH, specific conductance, temperature;
- Water level and product thickness meter;
- Water flow meters;
- Vapor flow meters;
- Air temperature probes;

- Flame ionization detectors; and
- Photoionization detectors.

Calibration and preventive maintenance procedures for this equipment, and any additional equipment that may be required for the project, are addressed Section 14 of the CQCPP and in SQP 8.2, Calibration and Maintenance of Measuring and Test Equipment. The PM will ensure that all equipment used in activities affecting quality will be calibrated according to these methods and procedures; laboratory directors, laboratory personnel, field superintendents, and field personnel will be responsible for implementing the procedures. Each item in the calibration program will be uniquely identified to assure its calibration status and identify the recalibration due date.

M&TE will be calibrated prior to use at the project site and at prescribed intervals thereafter, including at the completion of field work each day, in accordance with the manufacturers recommendations. Calibrations may be performed by trained and qualified personnel, approved outside agencies (such as equipment rental companies) or by the equipment manufacturer. Records of calibrations will be maintained by the CQCM for items used on-site. Approved laboratories will be required to implement an effective and documented calibration control program for measuring and test equipment used to perform analyses. The calibration program will be audited to verify conformance to laboratory protocols and project requirements. Calibration of each piece of equipment will be recorded on the Test Equipment List and Calibration form provided on Figure 14-1.

15. TEST CONTROL

This section describes the controls to be implemented to assess the performance of the three-well treatability test. Test control is addressed in Section 15 of the CQCPP and SQP 9.1, *Control of Tests*. The tests that will be conducted are identified in Figure 15-1, Testing Plan and Log. Tests will be conducted in accordance with procedures defined by UCB; Section 15.2 of the CQCPP addresses preparation of testing procedures.

As tests are performed, the Project Chemist or Project Geologist will record on the Testing Plan and Log, the date of the test, the date the test results were forwarded to the CQCM, and any remarks. The updated testing plan and log and a summary report of field tests is prepared monthly and attached to the last daily CQC Report of each month. For laboratory analytical testing, the Project Chemist will ensure that the requirements of the SAP are met as described in Section 15.7 of the CQCPP.

Test results are reported by the organization performing the test. The CQCM reviews the results of the test for conformance to the testing procedures and acceptance criteria then submits them to qualified technical review for approval of the results for use in project activities. The cover sheet for each test report provided by an analytical laboratory is conspicuously stamped at the laboratory in large red letters "CONFORMS" or "DOES NOT CONFORM" The CQCM documents the review of all test reports and includes a statement that the item tested or analyzed conforms or fails to conform to specified requirements. Upon completion of the review, the results are certified and test reports, certifications, and other documentation are submitted to the ROICC by the CQCM.

16. NONCONFORMANCE CONTROL AND CORRECTIVE ACTIONS

Items, processes, and services that do not meet established requirements during the three-well treatability test will be identified and controlled. Deficiencies which may be reworked to original will be identified on an outstanding items list until corrected. A Nonconformance Report (NCR) (Figure 16-1) will be prepared when an deficiency is identified which cannot be immediately corrected or is repetitive in nature. The Nonconformance report will include the following:

- the individual(s) identifying or originating the nonconformance;
- a description of the nonconformance;
- any required approval signatures;
- method(s) for correcting the nonconformance (corrective action) or a description of the variance granted; and
- a schedule for completing the corrective action.

All deficiencies will be documented by the CQCM on the Nonconformance Tracking log (Figure 16-2). Nonconformances will be documented and controlled in accordance with SQP 10.1, *Nonconformance Control*.

Corrective Action Requests (CAR), Figure 16-3, are used to identify, document, and provide actions to correct conditions or trends which are determined to be significantly adverse to quality and to provide methods to prevent their recurrence. Corrective actions to prevent recurrence of a nonconformance will be implemented in accordance with SQP 10.2, *Corrective Action*.

The CQCM has the authority to stop or control further processing of activities that, in the opinion of the CQCM, are uncontrolled or unconforming and, if not corrected, could affect the quality of the overall project or jeopardize the accomplishment of project goals or quality objectives. Stop work actions are coordinated through the PM and PI and will only be implemented when conditions exist which cannot be resolved through the nonconformance system or normal remediation construction processes. Conditions which threaten the safety, health, the public, or the environment are brought to the attention of the Program Certified Industrial Hygienist for action, unless the conditions pose an immediate danger, in which case the work is stopped immediately by the CQCM, PM, Site Superintendent, or individual responsible for the work being performed. The procedures and authorities for implementing the Stop Work Order are described in SQP 10.3, Stop Work Order.

17. CHANGE CONTROL

This section describes the procedures that will be implemented in the event changes or departures are required to this CQCP, the Work Plan, or established procedures and requirements for the three-well treatability test.

17.1 REQUEST FOR INFORMATION

Changes may be required when presumed information must be altered based on actual conditions

discovered during the three-well treatability test at Site 13 or when events occur in the field. Changes and/or clarifications considered minor by the PM (those that will not impact the cost or schedule of the project) may be made in the field through the use of a Request For Information (RFI) form. The PM will complete the RFI form and will submit it to the CQCPM and Program Managers as soon as is possible or practical, and not later than five days after determining or discovering the need for change or clarification. The Program Manager will then submit the RFI to the appropriate U.S. Navy personnel. The appropriate UCB or U.S. Navy personnel will provide the required responses or information as soon as possible.

17.2 FIELD WORK VARIANCE

Requests for changes that may or will affect the cost or schedule of the pilot-scale treatability study at Site 13 must be submitted by the PM and CQCPM to the Program Manager using the Field Work Variance (FWV) form, Figure 5-1. Prior to submittal, the completed FWV will be reviewed by the Site 13 CQCM to verify that all quality requirements are maintained. The Program Manager will submit the request to the appropriate personnel of the U.S. Navy. The procedures for implementation of the FWV process are described in SQP 11.1.

The effect of the change(s) on the project will be evaluated by the Project Manager, PI, UCB Program Manager, the CQCM and the U.S. Navy. Written approval must be provided for changes affecting the pilot-scale treatability study activities at Site 13 prior to the implementation of any significant change(s).

18. AUDITS AND SURVEILLANCE

Quality system and performance based audits of treatability study activities, including design, procurement, drilling, sample collection, etc., will be performed in accordance with applicable procedures. The CQCM will be responsible for surveillance of site activities on a daily basis, and the conduct of audits to verify compliance with the work plans, applicable procedures, and requirements of the CQCPP and CQCP.

The CQCM will prepare an audit schedule based on the planned site activity. Quality audits will be planned, performed, and reported in accordance with SQP 12.1, *Quality Audits*. Quality surveillance of in-process activities will be conducted in accordance with SQP 12.3, *Quality Surveillance* to verify compliance with the applicable standard operating procedure and CQCP requirements.

19. RECORDS MANAGEMENT

Records management, including the indexing, filing and storage of the project files, will be performed only by authorized personnel. The records are maintained in a central filing system at the BERC offices; the index is provided in Figure 19-1. The Deputy Program Manager has the overall responsibility for the management of records, including but not limited to providing for adequate storage facilities, maintenance of those facilities and assuring implementation of all records management activities. He/she will designate in writing those personnel authorized to remove program records from the records file area. The PM is responsible for the collection, maintenance and control of all records, including all reports. The control of records is monitored by the CQCM. All forms of documentation relating to the pilot-scale treatability study, including but not limited to paper and electronically stored documents, photographs, video/audio tapes and physical samples are considered "records". Procedures and practices for the control, handling, and

storage of records are addressed in Section 19 of the CQCPP and in SQP 4-2.

20. REPORTING

This section summarizes the reporting requirements that are referenced throughout this CQCP. The reporting requirements are summarized in Table 20-1 and include the following:

- Daily Contractor Production Report Required for each day field work is performed and will usually be attached to the daily CQC Report prepared for the same day and submitted to the ROICC by 10 AM the following work day. When only manual field activities are in progress, such as hand augering, the CQC report may be submitted weekly.
- Daily QC Report Required for each day that field work is performed, every 7 days when manual sampling is the only work, and every month during a no-work period, accounting for each calendar day of the contract. The report will be prepared, signed, and dated by the -CQCM. The report will identify the control phase, the definable feature of work, results of the inspections, a list of rework items, including status, any pertinent remarks. The report will be submitted to the ROICC by 10 AM the following work day;
- Field Activity Daily Log Submitted as an attachment to the Daily QC Report;
- Preparatory Inspection Report Submitted as an attachment to the Daily QC Report;
- Initial Inspection Report Submitted as an attachment to the Daily QC Report;
- Follow-up Inspection Report Submitted as an attachment to the Daily QC Report;
- Field Work Variance Report Submitted as an attachment to the Daily QC Report;
- As-Built Records The CQCM will submit a certificate to the ROICC attesting to the accuracy
 of the as-built records; and
- Certificate of Completion The CQCM will submit a Certificate of Completion to the ROICC
 at the completion of a scope of work attesting that the work has been completed, inspected,
 and tested and is in compliance with the requirements of the D.O.

The CQCM, or technical personnel as assigned, is responsible for reviewing and/or completing the Field Activity Daily Log/Quality Control Report, Field Work Variance Report, Nonconformance Report, Corrective Action Requests, Preparatory Inspection Report and other reports, as required. Detailed descriptions of reporting requirements are provided in Sections 20.0 through 20.5 of the COCPP.

The Quality Control (QC) Reports will be prepared, signed and dated by the CQCM and contain the following information:

- control phase and the definable feature of work;
- results of the preparatory phase meetings held, including the location of the definable feature of work and a list of personnel present at the meeting;
- results of the initial phase meetings held, including the location of the definable features of work and list of personnel present at the meeting;

- results of the follow-up phase inspections held;
- rework items identified;
- rework items corrected from the rework items list along with corrective actions taken;
- "Remarks" section; and
- contractor quality control report certification.

The CQCM shall prepare the minutes of the QC meetings and provide a copy to the U.S. Navy Contracting Officer within two working days after the meeting. The original and one copy of the Contractor Quality Control Report will be submitted by 10 A.M. the next working day after each report is prepared.

21. REFERENCES

CONTRACTOR QUALITY CONTROL PROGRAM PLAN
STANDARD QUALITY PROCEDURES
STANDARD OPERATING PROCEDURES

TABLES

Table 4-1 Applicable Standard Operating Procedures and Standard Quality Procedures

Title	Number
STANDARD OPERATING PROCEDURES	
Chain of Custody Sample Handling, Packaging and Shipping	1.1 2.1
Subsurface Soil Sampling While Drilling Drilling and Heavy Equipment Decontamination	3.2 6.2
Monitoring Well Installation Groundwater Sampling	8.1 9.1
Cone Penetration Sampling and Hydropunch Groundwater Sampling Aquifer Testing	10.2 11.1 17.1
Sample Labeling Sample Numbering Field QC Sampling	17.1 17.2 18.1
STANDARD QUALITY PROCEDURES	
Indoctrination and Training	3.2
Document Control Records Management	4.1 4.2
Preparation, Revision and Approval of Plans and Procedures Preparation, Review, and Approval of Procurement Documents	5.1 6.1
Calibration and Maintenance of Measuring and Test Equipment Control of Tests	8.2 9.1
Nonconformance Control Corrective Action Stop Work Order	10.1 10.2 10.3
Stop Work Order Field Work Variance/Request for Information Quality Audits	10.3 11.1 12.1
Quality Surveillances	12.3

Table 8-1
Summary of Data Quality Objectives for Three-Well Treatability Test

Stage of DQO Process

Description of Activities

Statement of Problem

The three-well treatability test is the first phase of a pilot-scale treatability study designed to obtain field performance data to assess the ability of Steam Enhanced Extraction (SEE) to mobilize free-phase hydrocarbons and remove volatile hydrocarbon components from the oily materials in the subsurface at Site 3. Removal of these hydrocarbons may result in a reduction in risk of exposure to the hydrocarbons remaining in place after application of steam.

The pilot-scale treatability study is funded through Delivery Order 3 to the U.S. Navy and UCB Partnership Agreement, issued by the U.S. Navy. The study will utilize resources from UCB, LBNL, LLNL, and subcontractors to UCB. The results of the three-well treatability test will be presented in a letter report that will be reviewed by the U.S. Navy, and Remedial Advisory Board (RAB) and used in making a decision whether to proceed with the 15-well pilot-scale test, the second phase of the treatability study.

Identify Decision

If the results of the three-well treatability test indicate that a suitable steam zone can be maintained at Site 13 and that SEE is capable of removing a sufficient mass of free phase or volatile hydrocarbons from the oily materials, a decision may be made to proceed with the 15-well pilot-scale test. If the results of the pilot-scale treatability study demonstrate that SEE can significantly reduce the risk to groundwater and/or future site occupants posed by the subsurface oily materials, the results would be utilized by the U.S. Navy and their contractor in a feasibility study or engineering estimate/cost analysis to evaluate whether SEE would be capable of reducing hydrocarbon concentrations to levels suitable for reuse of Site 13.

Identify Inputs

The three-well treatability test includes field and laboratory activities to (1) characterize the hydrocarbon concentrations and leachability before and after the application of steam; (2) measure the hydraulic conductivity of the water bearing materials (to be used for predicting system performance and sizing treatability equipment); (3) monitor temperature changes and gradients during application of steam; (4) monitor changes in soil resistivity during the application of steam; (5) monitor the performance of the effluent treatment system and measure the mass of hydrocarbons removed in the aqueous and gas phases; and (6) demonstrate compliance with discharge limitations established by EBMUD and the BAAQMD. A combination of established field and laboratory measurements will be required. Action levels are not appropriate for this treatability test because it is designed to measure the rate of hydrocarbon removal by SEE. The results will be used by the U.S. Navy in selecting a final remedial action for the Site 13.

Define Boundaries

Field sampling activities are centered around the location of Boring ALA13-P13 because hydrocarbons have been identified to a depth of approximately 17 feet at this location. Sampling activities will be conducted within the planned treatment zone (in the vicinity of this boring) to better define the vertical distribution of hydrocarbons in the soil and to characterize the concentrations and leachability of hydrocarbons within the treatment zone prior to and following the application of steam. The data are not expected to be seasonally dependent.

Operational sampling will be collected from the beginning of the three-well treatability test through completion of the test. Data collection is limited by ability to analyze amount of sample in effluent, and by costs of prolonged/repeated sampling efforts. Effectiveness of SEE will be evaluated by several criteria, including analysis of pre- and post-treatment soils as well as analyses of gas and aqueous effluents, and measurements of free phase hydrocarbon liquid.

Table 8-1
Summary of Data Quality Objectives for Three-Well Treatability Test

Stage of DQO Process

Description of Activities

Develop Decision Rule

If the results of the three-well treatability test indicate that SEE is capable of removing a significant mass of hydrocarbons from the subsurface, then SEE be included as part of the remedial action plan for Site 13. Concentrations of TPHg, TPHd, TPHmo, BTEX, PAHs, and metals as well as the leachability of BTEX will be measured in the pre and post demonstration samples and the results will be compared to estimate the quantity of hydrocarbons removed from the subsurface. Operational monitoring will be conducted to measure the mass of TPHg, TPHd, TPHmo, and BTEX in the aqueous and gas effluent streams. No action levels have been established.

Specify Limits on Decision Error

Section 10 of the CQCPP establishes required detection limits for the parameters that will be analyzed. False positives may occur because the removal rates and amounts may be overestimated due to limited sampling points. False negatives may also occur if the removal rates are underestimated due to limited sampling points. These possibilities will be minimized by complimentary analyses of pre- and post-treatment soil as well as effluent monitoring. Field blanks will be analyzed to establish that field contamination of samples has not occurred. All data will be validated to assess the acceptability and uncertainty of the data; the results of complementary analyses will be used to provide a mass balance, thereby mitigating false positive/negative conclusions regarding hydrocarbon removal rates.

Optimize the Design

Sections 2 through 4 of the Work Plan present an evaluation of existing site data, including an assessment of the lateral and vertical extent of hydrocarbons in the soil. Section 1 of the Sampling and Analysis Plan for the Three-Well Treatability Test (Appendix F of the Work Plan) includes sampling activities to provide a more detailed assessment of the hydrocarbon concentrations and the vertical extent of hydrocarbons within the planned treatment zone. These data will be used to adjust the planned locations and screened intervals of the injection/extraction wells, as appropriate. The SOPs include more specific descriptions of some of the planned sampling activities. Aquifer testing, will be conducted to measure the transmissivity and storativity of the water bearing materials and this information will be used to refine the specified sizing of the effluent treatment system equipment prior to procurement of the equipment.

TABLE 20-1 SUMMARY OF REPORTING REQUIREMENTS

Responsible Person	Report	Purpose of Report
CQCM or assigned person	Field Activity Daily Log	To document the results of daily activities.
Project Manager or CQCM as delegated	Field Variance Report (FVR)	To document procedural or material changes that may be required due to unforeseen events or inaccurate assumptions made during the development of plans, specifications and procedures. In general, changes which affect the cost or schedule of work will be made through the use of a FVR form. Minor changes and clarifications can be made in the field using RFI forms.
Any individual assigned to the project	Nonconformance Report (NCR)	The NCR will summarize a discrepancy or nonconformance with the scope of work. The NCR is sent to the PCQCM/CQCM for review. After this review is complete, the NCR is forwarded to the responsible organization for determining and documenting the appropriate disposition.
PCQCM or CQCM	Corrective Action Request (CAR)	The CAR documents conditions that are significantly adverse to project quality.
PCQCM or CQCM	Preparatory Inspection Report (PIR)	The PIR documents the results of Preparatory Phase inspections, and will be included as an attachment to the Daily QC Report submitted to the client.
PCQCM or CQCM	Initial Phase Inspection Report (IPIR)	The IPIR documents the results of Initial Phase inspections. Concurrence with the workmanship and inspection criteria for the feature of work will be established in the initial phase inspection. The following attributes will be addressed:
		 Establish quality of workmanship and inspection levels Resolve conflicts Verify work conforms to the SSHP and Hazard Analysis

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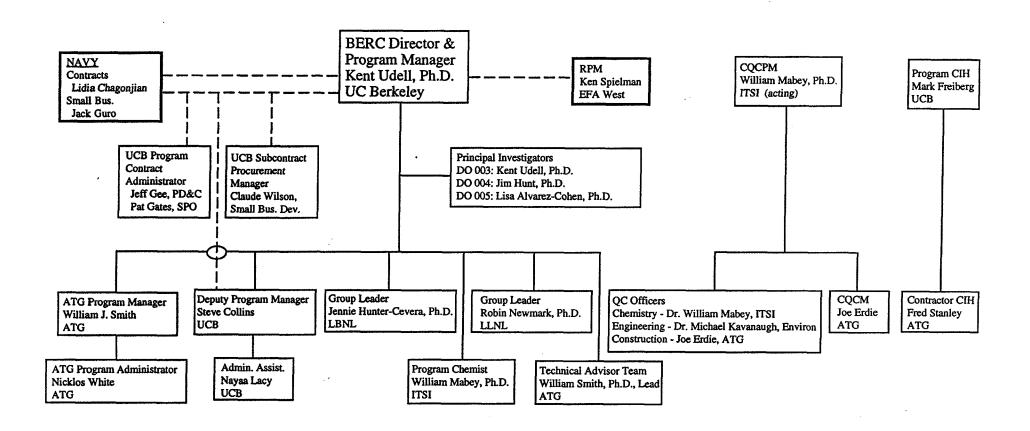
TABLE 20-1 continued SUMMARY OF REPORTING REQUIREMENTS

Responsible Person	Report	Purpose of Report
PCQCM or CQCM	Follow-up Phase Inspection Report (FPIR)	The FPIR documents the results of Follow-up Phase inspections. Follow-up inspections will be documented on a Follow-up Inspection Report, and will be included in or as an attachment to the Daily QC Report. Follow-up inspections reports will document the following: - Verifying work complies with the specification requirements - Verifying quality of workmanship is maintained - Verifying required tests are made - Verifying nonconforming conditions are identified and any rework is corrected.

FIGURES

Program Management Organization Chart

Berkeley Environmental Restoration Center, UC Berkeley



LEGEND

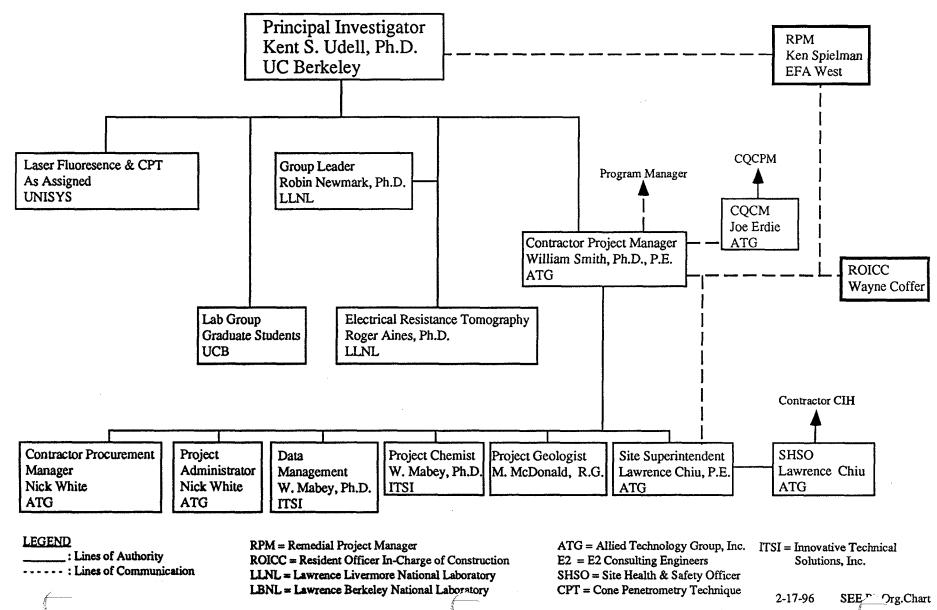
: Lines of Authority

SPO = UCB Sponsored Projects Office
PD&C = UCB Planning Design & Construction
BERC = Berkeley Envinronmental Restoration Center
CIH = Certified Industrial Hygienist
EFA West = Engineering Field Activity West

ATG = Allied Technology Group, Inc.
Environ = Environ International Corporation
LBNL = Lawrence Berkeley National Laboratory
LLNL = Lawrence Livermore National Laboratory
ITSI = Innovative Technical Solutions, Inc.

Steam Enhanced Extraction/DO 003 Project Organization Chart

Berkeley Environmental Restoration Center, UC Berkeley



PERSONNEL QUALIFICATION EVALUATION AND VERIFICATION

	Project Number:
PERSON EVALUATED: _	
ORGANIZATION/GROUP:	
The above-named individual experience and training, as qualified to perform tasks in	I has been evaluated on the basis of his/her current education, work represented in the attached documents, and has been found to be a the following areas:
1.	
2	
	-
These qualifications have tknowledge.	peen verified and found to be true and correct to the best of my
Signed:	Title:
Date:	
Additional training is recon	nmended in the following subjects.
1.	
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TRAINING ATTENDANCE RECORD

Subject:		D	ate:
Instructor:	Location:	C	ontact Hours:
Brief Course Descriptio	n:		
Name .	Signature	Organization/Project	Position
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FIGURE 4-2

EV.0 8/7/91

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PROJECT NAME		DATE	
CONTRACT NO.	DELLV	ERY ORDER NO.	
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(INCLUDE PRESENT REQUIREMENTS)		REQUIRED BY:	
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PROPOSED CHANGE			
TECHNICAL JUSTIFICATION			
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COST/SCHEDULE IMPACT			
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REASON FOR CHANGE	ADDITION	DELETION	
CHANGE ORDER REQUIRED	NO	YES	CHANGE ORDER NO
APPLICABLE DOCUMENT			
CC:			
VLLKOAET RI	Project Director	DATE	

TRANSMIT	TAL OF SHOP DRAWING, EQU MANUFACTURE'S CERTI	JIPMENT DATA, MATERIAL SA FICATES OF COMPLIANCE	AMPLES, OR	Date		· · · · · · · · · · · · · · · · · · ·	Transmittal No		
	(Read Instructions on the reverse	side prior to initiating this form)		<u> </u>					
То:	Section I - RE	QUEST FOR APPROVAL OF THE FOL From: Berkeley Environment		CONTRAC	nitiated by the T NO	contractor)	CHECK ONE:	THIS IS A NEW	TRANSMITTAL.
		230 Hesse Hall, Unive Berkeley, CA 94720	rsity of California					THIS IS A RESU TRANSMITTAL	
SPECIFICATION SEC NO ((Cover only one section with each	PROJECT TITLE AND LOCATION							
1 T E k N O	DESCRIPTION OF ITEM SUB (Type, size, model number,		MFG. OR CONTR CAT., CURVE DRAWING OR BROCHURE NO. (See instruction No 8)	NO. OF COPIES	SPEC PARA NO.	REFERENCE IMENT DRAWING SHEET NO.	FOR CONTRACTOR USE CODE	Instruction No.6)	FOR C E USE CODE
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	and the second s								
2574.240	Debrei ev e	NVIRONMENTAL RESTORATION CE	NTCD						
REMARKS	Approved	oted on submittal data and/or attached sheet	I certify that the above submitted items have been reviewed					ce with the xherwise stated	
		SECTION II	· APPROVAL ACTION		NAI	ME AND SIGN	NATURE OF CON	TRACTOR	
ENCLOSURES RETURNE	D (List by Item No.)		NAME, TITLE AND SIGNA	TURE OF A	PPROVING A	UTHORITY		DATE	

FIGURE 6-1 (FRONT SHEET)

INSTRUCTIONS

- 1. Section will be initiated by the Contractor in the required number of copies.
- 2. Each transmittal shall be numbered consecutively in the space provided for "Transmittal No." This number, in addition to the contract number, will form a serial number for identifying each submittal. For new submittals or resubmittals mark the appropriate box; on resubmittals, insert transmittal number of the last submissions as well as the new submittal number.
- 3. The "Item No." will be the same as "Item No." as indicated on ENG FORM 4288 for each entry on this form.
- 4. Submittals requiring expeditious handling will be submitted on a separate form.
- 5. Separate transmittal form will be used for submittals under separate section of the specifications.
- 6. A check shall be placed in the "Variation" column when a submittal is not in accordance with the plans and specifications -- also, a written statement to that effect shall be included in the space provided for "Remarks."
- 7. Form is self-transmittal, letter of transmittals is not required.
- 8. When a sample of material of Manufacture's Certificate of Compliance is transmitted, indicate "Sample" or "Certificate" in column c. Section I.
- 9. U. S. Army Corps of Engineers approving authority will assign action codes as indicated below in space provided in Section I, column i, to each item submitted. In addition they will ensure enclosures are indicated and attached to the form prior to return to the contractor. The Contractor will assign action codes as indicated below in Section I, column g. to each item submitted.

THE FOLLOWING ACTION CODES ARE GIVEN TO ITEM SUBMITTED

A -- Approved as submitted

E -- Disproved (See attached)

B .. Approved, except as noted on drawing

F -- Receipt acknowledged

C -- Approved, except as noted on drawing

FX -- Receipt acknowledged, does not comply

Refer to attached sheet resubmission required

as noted with contract requirements

D -- Will be return by separate correspondence

G -- Other (Specify)

10. Approval of items does not relieve the contractor from complying with all the requirements of the contract plans and specification.

DOCUMENT RECEIPT ACKNOWLEDGMENT

THE FOLLOWING CONTROLLED COPY

Copy No: _	
THEREOF ARE BEING TRANSM	PRISE THE BERC WESTDIV ALAMEDA PROJECT OF PORTIONS INTED FOR YOUR IMPLEMENTATION AND USE. PLEASE TRANSMITTAL ACKNOWLEDGING YOUR RECEIPT OF THE
DOCUMENT NAME:	
DOCUMENT REVISION:	
ISSUED TO AND LOCATION: _	
-	
I HAVE RECEIVED THE ABOVE	E LISTED DOCUMENTS
Name (Printed):	
Name (Signed):	
Company Name/Office:	
Date Received:	
PLEASE COMPLETE THIS RECI	EIPT AND RETURN TO:

BERKELEY ENVIRONMENTAL RESTORATION CENTER 230 HESSE HALL, UNIVERSITY OF CALIFORNIA BERKELEY, CA 94720

SUBMITTAL REGISTER CONTRACT NUMBER N6274-94-D-7430 THREE-WELL TREATABILITY TEST SITE 13, NAS ALAMEDA Delivery Order 0003

						TYPE	OF	SUB	мп	TAL			F	CLAS ICAT	SI- ION			CONTRA	CTOR SCHED	ULE DATE	CON	TRACTO	RACTION	GOVT A	ACTION	
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Trans- mittal No.	Item No.	Specification Paragraph No.	Description Of Item Submitted	A	S	S	S	S	S	S	S	S	N	Y	T	D	R	Submit	Approval Needed By	Material Needed By	Code	Date	Submit To Government	Code	Date	Remark(s)
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	1		As- Built Record Drawings		X							х	x													Submit at completion of D.O.
	2		As- Built Record - Material		x							х	7													Submit at completion of D.O.
	3	Contract	Work Plan			×	×								T	×		3/20/96								Submit Following DO Award
	4	Contract	Site Health and Safety Plan			x										×		3/20/96								Submit Following DO Award
	5	Contract	Environmental Protection Plan	Γ		×										×		3/20/96								Submit Following DO Award
	6	Contract	Contractor Quality Control Plan			x									1	×	\neg	3/20/96					-			Submit Following DO Award
	7	Contract	Process and Instrumentation Diagram		x											x										Submit Following DO Award
	8	Contract	Letter Report										X													Submit 60 Calendar Days Following Completion of Field Work
	9	රුව	CQC Meeting Minutes						X				X			1			,							Submit two days after meeting
	10	ග්ය	Daily Quality Control Report						X				×													Submit daily or weekly. For periods of non-work submit monthly.

SUBMITTAL REGISTER CONTRACT NUMBER N6274-94-D-7430 THREE-WELL TREATABILITY TEST SITE 13, NAS ALAMEDA Delivery Order 0003

					TYPE OF SUBMITTAL					CLASSI- FICATION					CONTRA	CTOR SCHED	ULE DATE	CON	TRACTO	R ACTION	GOVT A	ACTION				
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	13	άα	Field Variance Report		\neg				×				x	丁		\exists										
	14	ග්ය	Nonconformance Report						x				x													
	15	ග්ය	Corrective Action Requests						x				x													
	16	ග්ය	Preparatory Inspection Report						x				x													
	17	රේය	Initial Phase Inspection Report						x				x													
	18	άα	Pollowup Phase Inspection Report						×				x													
	19	රුග	Certification of Completion							x			x													Submit at completion of D.O.

CONTRACTOR REPORT DAILY QUALITY CONTROL (ATTACH ADDITIONAL SHEETS IF NECESSARY)

			Page	of
				Report No.
Contract No.	Delivery Order No.	Pro_	ject No	Date
SUMMARY OF THRE	EE PHASE INSPECTIONS M.	ADE TODAY:		
(Identify number perfort	med and attach descriptions on c	ontinuation pages)		
PREPARATORY INSP	ECTION(S):			
INITIAL INSPECTION	(5)			
FOLLOW-UP INSPECT	ITION(S)		,	
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DAILY CONTRACT REPORT PRODUCTION

				Page_	of	
Contractor		···	Superintendent		······	
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Title and Location						
Site Conditions						
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WAS A JOB SAFETY MEETING HELD THIS DAY?__YES__NO (If yes attach copy of the meeting minutes)
WERE THERE ANY LOST TIME ACCIDENTS THIS DATE?__YES__NO

(If yes attach copy of complete OSHA report)

WAS TRENCHING/SCAFFOLD/HV ELECTRICAL/HIGH WORK DONE?_YES_NO

(if yes attach statement or checklist showing inspection performed)

WAS HAZARDOUS MATERIAL/WASTE RELEASED INTO THE ENVIRONMENT?_YES_NO

(If yes attach description of incident and proposed action)

LIST SAFETY ACTIONS TAKEN TODAY/SAFETY INSPECTIONS CONDUCTED

SAFETY REQUIREMENTS HAVE BEEN MET_YES_NO

DAILY CONTRACT REPORT PRODUCTION

Contractor		Superintendent	Page	of
Contractor Contract No.	Delivery Order No.	anbermienden	Project No.	Date
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CONTRACTOR'S SUPERINTENDENT'S REMARKS

Berkeley Environmental Restoration Center

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FIELD ACTIVITY DAILY LOG

PROJECT NAME	PROJECT NO.
PROJECT ACTIVITY SUBJECT:	
DESCRIPTION OF DAILY ACTIVITIES AND EV	ENTS:
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VISITORS ON SITE:	CHANGE FROM PLANS AND SPECIFICATION, AND
	OTHER SPECIAL ORDERS AND IMPORTANT DECISIONS.
WEATHER CONDITIONS:	IMPORT TELEPHONE CALLS:
	,
BERC PERSONNEL ON SITE	
SIGNATURE	DATE:

EXAMPLE

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SAMPLE COLLECTION LOG

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FIGURE 9-1

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LEGEND

- 1. A SAMPLE COLLECTION LOG IS TO BE COMPLETED FOR EACH SAMPLE.
- 2. ALWAYS COMPLETE BOTH SIDES, IF SECOND SIDE IS NOT USED. DRAW A LINE THROUGH IT AND MARK N/A FILL IN CONTROL BLOCK AND PREPARED BY
- 3. ALL ENTRIES ON LOG ARE TO BE COMPLETED, IF NOT APPLICABLE MARK N/A.
- 4 DATE: USE MONTH/DAY/YEAR; I.E., 10/30/85
- 5 TIME, USE 24-HOUR CLOCK: 1 E., 1835 FOR 6:35 P.M.
- 6. PAGE: EACH SAMPLE TEAM SHOULD NUMBER PAGE ______ OF _____ FOR THE DAY'S ACTIVITIES FOR ALL SHEETS PREPARED ON A SINGLE DAY I.E., IF THERE ARE A TOTAL OF 24 PAGES (INCLUDING FRONT AND BACK) NUMBER 1 OF 24, 2 OF 24 ETC.
- 7. SAMPLE LOCATION: USE BORING OR MONITORING WELL NUMBER, GRID LOCATION (TRANSECT), SAMPLING STATION I D., OR COORDINATE TO PHYSICAL FEATURES WITH DISTANCES, INCLUDE SKETCH IN COMMENT SECTION IF NECESSARY.
- 8 SAMPLE TYPE, USE THE FOLLOWING SOIL, WATER (SURFACE OR GROUND). AIR (FILTERS, TUBES, AMBIENT, PERSONNEL), SLUDGE: DRUM CONTENTS, OIL, VEGETATION, WIPE, SEDIMENT
- 9 COMPOSITE TYPE. I.E., 24-HOUR, LIST SAMPLE NUMBERS IN COMPOSITE, SPATIAL COMPOSITE.
- 10 DEPTH OF SAMPLE, GIVE UNITS, WRITE OUT UNITS SUCH AS INCHES, FEET DON'T USE "OR"
- 11 WEATHER APPROXIMATE TEMPERATURE, SUN AND MOISTURE CONDITIONS
- 12 CONTAINERS USED LIST EACH CONTAINER TYPE AS NUMBER, VOLUME, MATERIAL (E.G. 2 IL GLASS, 4 40 ML GLASS VIAL, 1 400 ML PLASTIC 1 3 INCH STEEL TUBE 1 8 OZ. GLASS JAR1
- 13 AMOUNT COLLECTED VOLUME IN CONTAINERS IE G 1 2 FULL

Pro	10.:				Field	Log	bo().:				Date	:		Serial No	.:(882	٥.
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FIGURE 9-2 CHAIN OF CUSTODY FORM

EXAMPLE

FIGURE 12-1: MANUSCRIPT ROUTING FORM

Project Number	(check all those that apply)
. rojest rumbs.	WORDPROCESSING
Project Name	Wordprocess/spellcheck
Document Type	Format
# of Figures Location	EDITING
# of Tables Location	Developmental review
Attachments (Appendix Contract	Level 1 - minimal edit (see Levels of Edit)
(Appendix, Contract, Approval/Acceptance)	Level 2 - STANDARD EDIT
DELIVERY	Level 3 - intensive edit
	Same day letter (scheduled by noon)
Due Date:	Writer(s) Project Project Illustrate
Deliver via:	Peer Final Reviewer
In-house	File locations and names:
Due Date:	L:\LFPUBLIC\
Deliver via:	Editor's Notes:
In-house	
Date Initials	Comments/Instructions
•	
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*:	

DEFINABLE FEATURES OF WORK CONTRACT NUMBER N6274-94-D-7430 THREE-WELL TREATABILITY TEST SITE 13, NAS ALAMEDA Delivery Order 0003

			Prepa	ratory	Ini	tial		
Specification Section	Para No.	Feature of Work	Req	Date	Req	Date	Follow-up Req	Remarks
Work Plan	9.1.2.3	Utility Clearance	Х		X		X	Completed prior to site mobilization
Work Plan	9.1.2.4	Cone Penetrometer Testing	X		X		Х	
Work Plan	9.1.2.5	Mobilization of Field Office Trailer and Establishment of Staging Area	Х		X		X	Completed prior to field work
Work Plan	9.1.2.7	Surveying of Ground Elevations and Grading	Х		Х		X	Initial survey performed for design information
Work Plan	9.1.2.8	Installation of Injection/Extraction Wells	Х		X		X	
Work Plan	9.1.2.9	Hydraulic Testing	Х		X		Х	
Work Plan	9.1.2.11	Installation of Temperature Observation Wells	Х		. X		Х	
Work Plan	9.1.2.11	Installation of Electrode Wells	X		X		X	
Work Plan	9.1.2.11	Installation of Groundwater Monitoring Wells	Х		Х		X	
Work Plan	9.1.2.12	Development of Groundwater and Injection/Extraction Wells	Х		Х		Х	
Work Plan	9.1.2.13	Survey Well Locations and Elevations	Х		Х		X	
Work Plan	9.1.2.14	Installation of Surface Containment System	Х		Х		Х	
Work Plan	9.1.2.15	Installation of Treatment System and Above-Ground Piping Network	х		Х		Х	
Work Plan	9.1.2.16	System Operation	Х		Х		Х	
Work Plan	9.1.2.17	Post Demonstration Sampling	Х		Х		Х	
Work Plan	9.1.2.18	System Decommissioning	Х		Х		X	

EXAMPLE

	FOR QUALITY CONTROL REPORT CONTINUATION SHEET DDITIONAL SHEETS IF NECESSARY)	Pageof
`	· · · · · · · · · · · · · · · · · · ·	Date
Contractor		Project No.
Contract No.	Delivery Order No	Report No.
	PHASE PREPARATORY	
•	Y-YES; N-NO, SEE REMARKS	
	BLANK-NOT APPLICABLE	
	THE PLANS AND SPECS HAVE BEEN REVIEWED	
	THE SUBMITTALS HAVE BEEN APPROVED	
	MATERIALS COMPLY WITH APPROVED SUBMITTALS	_
	PRELIMINARY WORK WAS DONE CORRECTLY	
	TESTING PLAN HAS BEEN REVIEWED	_
	WORK METHOD AND SCHEDULE DISCUSSED	
	Contractor's QC Representative	Date

EXAMPLE

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	DDITIONAL SHEETS IF NECESSARY		Date
ontractor			Project No.
ontract No.	Delivery Order No.		Report No.
		PHASE NITIAL	
	Y-YES; N-NO, SEE REMARKS		
	BLANK-NOT APPLICABLE		
	PRELIMINARY WORK WAS DONE CORRECT	TLY	
	SAMPLE HAS BEEN PREPARED/APPROVED)	
	WORKMANSHIP IS SATISFACTORY		
	TEST RESULTS ARE ACCEPTABLE		
	WORK IS IN COMPLIANCE WITH THE CON	TRACT	
ESTING F	PERFORMED & WHO PERFORMED) TEST(Include number of sam	oles and/or tests taken)
ESTING F	PERFORMED & WHO PERFORMED) TEST(Include number of sam	ples and/or tests taken)
ESTING F	PERFORMED & WHO PERFORMED	TEST(Include number of sam	oles and/or tests taken)
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ESTING F	PERFORMED & WHO PERFORMED	TEST(Include number of sam	ples and/or tests taken)
ESTING F	PERFORMED & WHO PERFORMED	TEST(Include number of sam	ples and/or tests taken)
ESTING F	PERFORMED & WHO PERFORMED	TEST(Include number of sam	ples and/or tests taken)
ESTING F	PERFORMED & WHO PERFORMED	TEST(Include number of sam	ples and/or tests taken)

EXAMPLE

-	ALITY CONTROL REPORT (NAL SHEETS IF NECESSARY)	CONTINUATION SHEET	Pageof
	oracio a recessitati		Date
ontractor			Project No.
ontract No.	Delivery Order No		Report No.
	F	PHASE OLLOW-UP	
Y-YES; N	I-NO, SEE REMARKS		
BLANK-I	NOT APPLICABLE		
WORK C	OMPLIES WITH CONTRACT AS APPRO	OVED IN INITIAL PHASE	
DENTIFY DEFINA	BLE FEATURE OF WORK, L	OCATION AND LIST PERSON	NEL PRESENT
		, , , , , , , , , , , , , , , , , , ,	
			*
ESTING PERFOR	MED & WHO PERFORMED T	EST(Include number of samples	and/or tests taken)
		<u></u>	
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		<u></u>	
		ontractor's OC Representative	Date

BERKELEY ENVIRONMENTAL RESTORATION CENTER		TEST EQ	UIPMENT LIST	Γ AND CALI	BRATION	I
PROJECT NAME:			_	PROJECT NO.		
EQUIPMENT NAME:			_ EQUI	PMENT TOLERANCE:		
Equipment Number and Use (Screening or Analytical)	Equipment Name (manufacturer and Model ID)	Date and Time (of Calibration)	Calibration Standard Used (manufacturer and Lot Number)	Equipment Reading (Include Units and Tolerances)	Comments (and/or Observations)	Initials (of Person)
					:	
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NOTE: COMPLETE CALIBRATION AND RECORD INFORMATION BERFORE USE FOR ALL TEST EQUIPMENT THAT REQUIRES CALIBRATION

TESTING PLAN AND LOG CONTRACT NUMBER N6274-94-D-7430 PILOT-SCALE TREATABILITY STUDY SITE 13, NAS ALAMEDA Delivery Order No. 0003

Reference/ Section	Test Procedure	Test Name	Approved Laboratory	Sampled By	Test Location	Frequency	Date Complete	Date To Contr. Ofc.	Remarks
App F / 1.2	SOP 10.2	Cone Penetrometer Testing				20 locations			
App F / 1.2		Laser Induced Fluorescence				20 locations			
App F / 1.5		Grain Size Analysis				4 per 3 borings			
App F / 1.5	8015 m	TPHg				19 samples			
App F / 1.5	8015 m	TPHd				19 samples			
App F / 1.5	8015 m	TPHmo				19 samples			
App F / 1.5	8100	РАН				13 samples			
App F / 1.5	8020	BTEX				14 samples			
App F / 1.5	6010/7471	Metals				13 samples			
App F / 1.5	9040	рН				19 samples			
App F / 1.5	8020	BTEX-RLP				6 samples			
App F / 2.7	8015 m	TPHg				18 samples			
App F / 2.7	8015 m	TPHd				18 samples			
App F / 2.7	8015 m	TPHmo				18 samples			
App F / 2.7	8100	РАН				18 samples			
App F / 2.7	8020	BTEX				19 samples			
App F / 2.7	6010/7471	Metals				12 samples			
App F / 2.7	8020	BTEX-TCLP				9 samples			

TESTING PLAN AND LOG CONTRACT NUMBER N6274-94-D-7430 PILOT-SCALE TREATABILITY STUDY SITE 13, NAS ALAMEDA Delivery Order No. 0003

Reference/ Section	Test Procedure	Test Name	Approved Laboratory	Sampled By	Test Location	Frequency	Date Complete	Date To Contr. Ofc.	Remarks
App F / 2.7	8015 m	TPHg				15 samples			
App F / 2.7	8015 m	TPHd				15 samples			
App F / 2.7	8015 m	TPHmo				15 samples			
App F / 2.7	8100	РАН				15 samples			
App F / 2.7	8020	BTEX				16 samples			
App F / 2.7	8015 m	TPHg				11 samples			
App F / 2.7	8015 m	TPHd				11 samples			
App F / 2.7	8015 m	TPHmo				11 samples			
App F / 2.7	8100	РАН				11 samples			
App F / 2.7	8020	BTEX				12 samples			
App F / 2.7	6010/7471	Metals				11 samples			
App F/5	8015 m	TPHg				1 sample			
App F/5	8015 m	TPHd				1 sample			
App F/5	8015 m	TPHmo				1 sample			
App F/5	8100	РАН				1 sample			
App F/5	8020	BTEX				1 sample			
App F/5	6010/7471	Metals				1 sample			
App F / 8.1	FID	ТРН				see Table 8-1 of App F			
App F / 8.1	FID	BTEX				see Table 8-1 of App F			
App F / 8.1	8015 m	TPHg				see Table 8-1 of App F			
App F / 8.1	8015 m	ТРНа				see Table 8-1 of App F			

Figure 15-1

TESTING PLAN AND LOG CONTRACT NUMBER N6274-94-D-7430 PILOT-SCALE TREATABILITY STUDY SITE 13, NAS ALAMEDA Delivery Order No. 0003

Reference/ Section	Test Procedure	Test Name	Approved Laboratory	Sampled By	Test Location	Frequency	Date Complete	Date To Contr. Ofc.	Remarks
App F / 8.1	8015 m	TPHmo				see Table 8-1 of App F			
App F / 8.1	8100	PAH				see Table 8-1 of App F			
App F / 8.1	8020	BTEX				see Table 8-1 of App F			
App F / 8.1	6010/7471	Metals				see Table 8-1 of App F			
App F / 8.2	FID	TPH				see Table 8-1 of App F			
App F / 8.2	FID	BTEX				see Table 8-1 of App F			
App F / 8.2	8015 m	TPHg				see Table 8-1 of App F			
App F / 8.2	8015 m	TPHd				see Table 8-1 of App F			
App F / 8.2	8015 m	TPHmo				see Table 8-1 of App F			
App F / 8.2	8100	PAH				see Table 8-1 of App F			
App F / 8.2	8020	BTEX				see Table 8-1 of App F			
App F / 8.2	6010/7471	Metals				see Table 8-1 of App F			
App F / 9.3	8015 m	ТРНg				28 samples			
App F / 9.3	8015 m	TPHd				28 samples			
App F / 9.3	8015 m	TPHmo				28 samples			
App F / 9.3	8100	PAH				28 samples			
App F / 9.3	8020	BTEX				29 samples			
App F / 9.3	6010/7471	Metals				23 samples			
App F / 9.3	8020	BTEX-TCLP				15 samples			

	NON-C	ONFORMANCE REPORT		
			DATE:	
CONTRACT NO.		DELIVERY ORDER NO.		
LOCATION:		-	NCR NO.	
DESCRIPTION	OF NON-CONFORMA	NCES:		
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	PREPARED BY:		DATE:	
		Quality Control Representative		
	REVIEWED BY:		DATE:	
		Quality Control Manager		
DISPOSITION:		··· ·· ··		•
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	RECOMMENDED BY		DATE:	
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	REVIEWED BY:	Quality Control Representative	DATE:	
		Quality Control Representative		
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ACTION VERIF	ICATION:			
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	REVIEWED BY:		DATE:	
		Quality Control Representative	,	
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HICK CLUSE OL) L		DATE:	
		Quality Control Manager	. DAIE:	
		Quarty Condor Manager		

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			TRACKING I	LUG			
CONTRACT NO.						PAGE	OF
DELIVERY ORDER NO.							
NCR NO.	ORIG DATE	INITIATED BY	NONCONFORMAC	E DESCRIPTION		STA	TUS .
PROJECT NO.	CLOSE DATE	CLOSED BY		RESP. PARTY	C/A DUE	C/A RECOMMENDED AND APPROVED	REINSPECTION RESULT
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Environmental				
Restoration Center				Í
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ADVERSE TREND: Yes	No			
Organization/Project/Department:			Person Contacted:	<u> </u>
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Discrepancy (includes Specific Requirements Violat	•4/•			
Discrepancy (nicious Specific Requirements Violet				1
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O de la constante de la consta		Response Due Date:		
Originator:		Response Due Date:		ł
				1
Corrective Action Taken/Proposed to Correct Discre	pancy:			
				-
			•	
Corrective Action Taken to Prevent Recurrence (the	cause of the discrep	ancy must also be incl	luded here):	
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				Ì
Committee Annual Committee		Date When Cornetto	re Action Will be Compared:	
Corrective Action Taken by (signature and title):		Date When Confectiv	e Action will be Compared.	
Corrective Action Evaluated:		Verification of Imple	mentation:	
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Evaluated By:	Date:	Verified By:		Date:
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TABLE 19-1 WESTDIV ALAMEDA PROJECT GENERAL FILE INDEX

Updated: 02/23/95

File No.	Description of File Contents
A.1	ORANGE Outgoing Correspondence From Home Office to Client
A.2	Incoming Correspondence From Client to Home Office
A.3	Outgoing Correspondence From Project Office to Client
A.4	Incoming Correspondence From Client to Project Office
A.5	Non-Procurement Outgoing Correspondence
A.6	Non-Procurement Incoming Correspondence
A.7	Record of Telephone Correspondence
A.8	Meeting Minutes/Agendas
A.9	Interoffice memos/In-House Correspondence
A.10	In-House Miscellaneous Police
Б	RESUMES AND AND AND AND AND AND AND AND AND AND
B.1	Individual Resumes (Outside of BERC)
B.2	Individual Resumes (BERC)
	·
***************************************	ORIGINAL COPIES OF PLANS AND SUBMITTALS AND WHITE
C.1	Work Plans/Cost Estimates
C.2	Health and Safety/CQC Plans
C.3	Environmental Protection Plans
C.4	Material Handling Plans
	Restoration and Revegetation Plans
C.6	Grading Plans
C.7	
C.8	
C.9	
C.10	Misc. Submittals/Plans (Not Specifically Listed In Index)
D	ESTIMATES/CONTRACTS YELLOW
***************************************	Prime Contract/Delivery Order/Task Order/Award
	Statement of Work/Specifications/Personnel Requirements
	Pre-Award/Amendments To Solicitation
	Proposal/Estimates/Cost Volume
	Certificates of Current Cost/Pricing Data
	Pricing Backup (Bid Books)
	Project Briefs
	Job Set-Up and Budget
	WBS (Work Breakdown Structure)
	Change Order Logs
	Mod/Change #1
	Mod/Change #2
	Mod/Change #3
	Mod/Change #4
	Mod/Change #5
	Mod/Change #6
	Mod/Change #7
	Mod/Change #8

D 00	14.0
D.9.9	Mod/Change #9
D.9.10	Mod/Change #10
D.10	Cost and Schedule Reports
D.11	Schedules
D.12	Project Manager's Status Report
D.13	Invoices to Client
D.14	Project Closeout Records
D.15	Certified Weekly Payrolls
D.16	Contract Negotiations
D.17	
D.18	
D.19	
D.20	California Preliminary Notices
FACE E	HELD DATA AND FIEED DATA CHECKPRINTS
E.1	Field Activity Daily Logs/Daily Site Reports
E.2	Survey Records
E.3	Sample Collection Logs
E.4	Boring and Trenching Logs
E.5	Calibration Records
E.6	Test Data Forms
E.7	Waste Manifests/Bills of Lading
E.8	Subcontractor Field Data
E.9	Other Field Data
E.10	Requests for Analysis/Chain of Custody Forms
	····· · · · · · · · · · · · · · · · ·
F	CALCULATIONS AND EALCULATION CHECKPRINTS
F.1	Calculation #1
F.1 F.1a	Calculation #1 Checkprint for Calculation #1
F.1 F.1a F.2	Calculation #1 Checkprint for Calculation #1 Calculation #2
F.1 F.1a F.2 F.2a	Calculation #1 Checkprint for Calculation #1 Calculation #2 Checkprint for Calculation #2
F.1 F.1a F.2 F.2a F.3	Calculation #1 Checkprint for Calculation #1 Calculation #2 Checkprint for Calculation #2 Calculation #3
F.1 F.1a F.2 F.2a F.3 F.3	Calculation #1 Checkprint for Calculation #1 Calculation #2 Checkprint for Calculation #2 Calculation #3 Checkprint for Calculation #3
F.1 F.1a F.2 F.2a F.3	Calculation #1 Checkprint for Calculation #1 Calculation #2 Checkprint for Calculation #2 Calculation #3 Checkprint for Calculation #3 Checkprint for Calculation #3 Calculation #4
F.1 F.1a F.2 F.2a F.3 F.3a F.4 F.4	Calculation #1 Checkprint for Calculation #1 Calculation #2 Checkprint for Calculation #2 Calculation #3 Checkprint for Calculation #3 Calculation #4 Checkprint for Calculation #4
F.1 F.1a F.2 F.2a F.3 F.3a F.3a	Calculation #1 Checkprint for Calculation #1 Calculation #2 Checkprint for Calculation #2 Calculation #3 Checkprint for Calculation #3 Calculation #4 Checkprint for Calculation #4 Calculation #5
F.1 F.1a F.2 F.2a F.3 F.3a F.4 F.4	Calculation #1 Checkprint for Calculation #1 Calculation #2 Checkprint for Calculation #2 Calculation #3 Checkprint for Calculation #3 Calculation #4 Checkprint for Calculation #4
F.1 F.1a F.2 F.2a F.3 F.3a F.4 F.4a F.5	Calculation #1 Checkprint for Calculation #1 Calculation #2 Checkprint for Calculation #2 Calculation #3 Checkprint for Calculation #3 Calculation #4 Checkprint for Calculation #4 Calculation #5
F.1 F.1a F.2 F.2a F.3 F.3a F.4 F.4a F.5 F.5a	Calculation #1 Checkprint for Calculation #1 Calculation #2 Checkprint for Calculation #2 Calculation #3 Checkprint for Calculation #3 Calculation #4 Checkprint for Calculation #4 Calculation #5
F.1 F.1a F.2 F.2a F.3 F.3a F.4 F.4a F.5 F.5a	Calculation #1 Checkprint for Calculation #1 Calculation #2 Checkprint for Calculation #2 Calculation #3 Checkprint for Calculation #3 Calculation #4 Checkprint for Calculation #4 Checkprint for Calculation #4 Calculation #5 Checkprint for Calculation #5
F.1 F.1a F.2 F.2a F.3 F.3a F.4 F.4a F.5 F.5a	Calculation #1 Checkprint for Calculation #1 Calculation #2 Checkprint for Calculation #2 Calculation #3 Checkprint for Calculation #3 Calculation #4 Checkprint for Calculation #4 Checkprint for Calculation #4 Calculation #5 Checkprint for Calculation #5
F.1 F.1a F.2 F.2a F.3 F.3a F.4 F.4a F.5 F.5a	Calculation #1 Checkprint for Calculation #1 Calculation #2 Checkprint for Calculation #2 Calculation #3 Checkprint for Calculation #3 Calculation #4 Checkprint for Calculation #4 Checkprint for Calculation #4 Calculation #5 Checkprint for Calculation #5
F.1 F.1a F.2 F.2a F.3 F.3a F.4 F.4a F.5 F.5a G.0	Calculation #1 Checkprint for Calculation #1 Calculation #2 Checkprint for Calculation #2 Calculation #3 Checkprint for Calculation #3 Calculation #4 Checkprint for Calculation #4 Checkprint for Calculation #4 Calculation #5 Checkprint for Calculation #5
F.1 F.1a F.2 F.2a F.3 F.3a F.4 F.4a F.5 F.5a G.0	Calculation #1 Checkprint for Calculation #1 Calculation #2 Checkprint for Calculation #2 Calculation #3 Checkprint for Calculation #3 Calculation #4 Checkprint for Calculation #4 Checkprint for Calculation #4 Calculation #5 Checkprint for Calculation #5 Checkprint for Calculation #5
F.1 F.1a F.2 F.2a F.3 F.3a F.4 F.4a F.5 G.1 G.2 H.H.H.1	Calculation #1 Checkprint for Calculation #1 Calculation #2 Checkprint for Calculation #2 Calculation #3 Checkprint for Calculation #3 Calculation #4 Checkprint for Calculation #4 Calculation #5 Checkprint for Calculation #5 Checkprint for Calculation #5 Checkprint for Calculation #5 Checkprint for Calculation #5 REPORTS FROM CEHERS PINK PLANS/SUBMITERALS/REPORTS BRUTE Work Plans/Cost Estimates
F.1 F.1a F.2 F.2a F.3 F.3a F.4 F.4a F.5 F.5a G.1 G.1 G.2	Calculation #1 Checkprint for Calculation #1 Calculation #2 Checkprint for Calculation #2 Calculation #3 Checkprint for Calculation #3 Calculation #4 Checkprint for Calculation #4 Checkprint for Calculation #4 Calculation #5 Checkprint for Calculation #5 REPORTS FROM OTHERS PINK PLANS/SUBMERTALS/REPORTS**
F.1 F.1a F.2 F.2a F.3 F.3a F.4 F.4a F.5 G.1 G.2 H.H.H.1	Calculation #1 Checkprint for Calculation #1 Calculation #2 Checkprint for Calculation #2 Calculation #3 Checkprint for Calculation #3 Calculation #4 Checkprint for Calculation #4 Calculation #5 Checkprint for Calculation #5 Checkprint for Calculation #5 Checkprint for Calculation #5 REPORTS FROM OTHERS PINK PLANS/SUBMERIALS/REPORTS Work Plans/Cost Estimates Health and Safety/CQC Plans
F.1 F.1a F.2 F.2a F.3 F.3a F.4 F.4a F.5 F.5a G.1 G.2 H.1 H.1 H.2 H.3 H.4	Calculation #1 Checkprint for Calculation #1 Calculation #2 Checkprint for Calculation #2 Calculation #3 Checkprint for Calculation #3 Calculation #4 Checkprint for Calculation #4 Calculation #5 Checkprint for Calculation #5 Checkprint for Calculation #5 REPORTS FROM OFFIERS PINK PLANS/SUBMERTATS/REPORTS BRUE Work Plans/Cost Estimates Health and Safety/CQC Plans Environmental Protection Plans Material Handling Plans
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